

**SURVEY AND ANALYSIS OF URBAN DRAINAGE ORDINANCES
AND A RECOMMENDED MODEL ORDINANCE**

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SURVEY AND ANALYSIS OF URBAN DRAINAGE ORDINANCES

AND A RECOMMENDED MODEL ORDINANCE

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SUMMARY

The major objective of this study was to draft a model urban drainage ordinance based on the problems, ordinances, and experiences of urban areas. In addition the use of technical information in drainage and erosion control ordinances was investigated, the use of hydrologic computer simulation in an urban drainage program was documented, and the objectives and problems associated with achieving those objectives through existing urban drainage programs were discussed.

This study deals with the interaction between the technical and the nontechnical aspects of practical drainage problems. Scientific principles and documented experiences do not always provide an adequate basis for dealing with these problems. Consequently, personal opinion, political pressure, expediency, past precedents, etc., are sometimes the dominant forces behind those actions that are adopted. A literature review, conducted as part of this study, indicated that there has been very little documentation from which to evaluate the effectiveness of urban drainage ordinances and programs. Some governmental agencies have written model drainage regulations, but little or no research has been done to determine the effectiveness of these ordinances or the problems in administering them. Thus, the direction taken in this study was to aggregate the experiences of several urban areas to provide as general as possible an information base for formulating a model ordinance.

Initial contacts were made with over 30 cities and counties throughout the United States to determine which areas had relevant experience

in dealing with urban drainage problems, whether they would be interested in participating in this study, and whether they felt they could benefit from the results of such a study. From these contacts the following communities were selected: Atlanta Metropolitan Area (City of Atlanta, DeKalb, Fulton, and Clayton Counties); Chicago, Illinois (Chicago Sanitary District); Fairfax County, Virginia; Ingham County, Michigan; and Tampa, Florida.

The drainage program in each of these communities was intensively studied through a review of all available publications, interviews with and a review of the files of the personnel involved in the local drainage program (both from within and outside the governmental structure), review of the local ordinances, and any other available documentation on the drainage program. This information was compiled into written case studies which were reviewed by several persons from each community to validate the accuracy of the material presented. These case studies then served as the data base for the model ordinance proposed in the thesis.

Accompanying the proposed model ordinance, commentaries document why each provision of the ordinance is included and how the model ordinance relates to the ordinances and drainage programs from the communities studied. It is intended that this model ordinance will serve as a guide to aid in the drafting of drainage ordinances for specific areas, and not be adopted verbatim without prior review of conditions affecting local applicability. The results of this study should be useful not only in the communities that were studied but in any urban or urbanizing area that is formulating or revising a drainage program.

CHAPTER I

INTRODUCTION

Erosion, sediment control, hydrologic and hydraulic studies, flood plains - these and other terms related to drainage are receiving substantial public attention in many urban areas throughout the country. Advances through research and experience are allowing engineers to become more sophisticated in their approach to urban drainage problems. At the same time, preliminary investigations in the Atlanta Metropolitan Area indicated that storm water management practices and drainage ordinances are taking little advantage of recent advances in urban drainage theory and the practices employed in communities with experience in urban drainage.

In order to take an in-depth look into the problems of urban drainage and drainage ordinances, a study of the drainage programs of several urban areas was undertaken. The results of this study are reported herein. The tasks involved in this study were as follows:

1. Select and study jurisdictions which have made a significant contribution to some aspect of urban drainage.
2. Develop a model urban drainage ordinance from the following data base:
 - a) information obtained from interviews with persons involved in the drainage program of the areas selected,

- b) information obtained from the personal and public files of the persons interviewed,
 - c) information gained from literature concerning the drainage programs under study,
 - d) general information from literature pertaining to urban drainage and drainage ordinances.
3. Outline and discuss a recent research project in DeKalb County Georgia, dealing with hydrologic computer simulation and relate this work to the urban drainage ordinance presented in this thesis.

In formulating this study it was assumed that the experiences, ordinances, and procedures of several urban areas could be used to document successes and/or failures of existing ordinances to fulfill their intended purposes and of difficulties in ordinance administration. Also the lessons learned from these experiences could be used as the basis for the formulation of an urban drainage ordinance that could be adopted by both urban and urbanizing areas.

The results of this study should be useful not only in the areas that were studied but in any urban or urbanizing area that is formulating or revising a drainage program. It is hoped that the experiences of the areas studied can be used by others to guide their development of an effective drainage program.

Development of the Study

The study was started in the fall of 1972. Initial contacts were made with engineering personnel from the city and county governments

within the Atlanta Metropolitan Area. From these contacts, it was determined that a study directed primarily at the formulation of an urban drainage ordinance was needed, wanted, and would be relevant to the drainage problems of urban areas. In the Atlanta Metropolitan Area, the City of Atlanta, DeKalb, Fulton, and Clayton Counties, and the Home Builders Association of Metropolitan Atlanta, agreed to participate and partially fund the study.

The next step in the study was to contact officials in over thirty cities and counties throughout the United States to determine which areas had relevant experience in dealing with urban drainage problems, whether they would be interested in participating in this study, and whether they felt they could benefit from the results of such a study. From these contacts, officials in twelve cities and counties agreed to participate but several had little experience in urban drainage or were just beginning to formulate their drainage programs. In the end, the following areas were selected and agreed to participate and augment the studies in the Atlanta Metropolitan Area: Chicago, Illinois; Tampa, Florida; Fairfax County, Virginia; and Ingham County, Michigan.

Following is a brief explanation of why each of these areas was selected:

1. Chicago, Illinois (Chicago Sanitary District) - The Chicago Sanitary District has had extensive involvement in almost every phase of urban drainage including computer simulation, drainage ordinances, flood plain regulations and other technical aspects of urban drainage.

2. Tampa, Florida - Tampa has recently done some innovative work pertaining to centralized detention storage facilities for flood control.
3. Fairfax County, Virginia - Fairfax County has an elaborate erosion and sediment control program which has been active for many years. The County is also involved in an extensive computer simulation program which is of interest in this study.
4. Ingham County, Michigan - At the time of this study, a computer simulation program dealing with flood and drainage problems throughout the County was being developed. Ingham County also had a drainage ordinance which included many aspects not found in the other ordinances studied.
5. Atlanta Metropolitan Area - The Atlanta Metropolitan Area was selected because of the local interest in urban drainage and flooding problems. The Atlanta Area also represented urban governments that were just beginning to formulate drainage ordinances and programs in contrast to several of the other areas studied which had been dealing with these subjects for many years.

Interview trips were then arranged to these cities and counties. Approximately one week was spent in each area interviewing public officials, engineering and planning personnel, engineering consultants, and other persons interested in urban drainage. After each of these trips the information obtained from the personal interviews and whatever literature or documents were available was compiled into case studies.

Thus, the case studies contain a great deal of information about the different drainage programs and problems encountered in administering them. Some of this information will be used to document the material contained in the next five chapters of this thesis. The primary function of the case studies is to present information about the drainage programs studied, as related by the individuals interviewed.

All of the case studies were sent back to the cities or counties for their review and comment. Copies of the case studies were sent for evaluation and comment to the offices of the Home Builders Association in the areas studied. The case studies from the Atlanta Metropolitan Area were reviewed by personnel from the U.S. Army Corps of Engineers, Consulting Engineers working on the Atlanta Urban Study, and the Atlanta Regional Commission. Thus the accuracy of the information presented was validated by having persons outside the city or county structure read and comment on the individual case studies. A copy of each case study is included in the Appendices.

During this same period, a literature search was conducted to determine what advances in the area of urban drainage (specifically hydrology) could be applied to an urban drainage program.

With the literature search and case studies as background material the main body of this thesis was written. Since the author has been working as a Drainage Engineer for Cobb County, Georgia (another of the Atlanta Metropolitan Counties) during most of the time that this research was being conducted, his experiences with this County have been cited in several sections of this thesis.

Study Criteria

This study deals with the technical and nontechnical aspects of practical drainage problems. Scientific principles and/or documentation of previous results are not always adequate as a basis for dealing with these problems. Personal opinion, political pressure, expediency, past precedents, etc., are sometimes the dominant forces behind adopted solutions. A literature review, conducted as part of this study, indicated there has been very little documentation of urban drainage practices and ordinances. Several governmental agencies have written model regulations for flood plains (similar to reference 25) but little or no research has been done to determine the effectiveness of these ordinances or problems in administering them.

The direction taken in this study is to use the experiences of several urban areas as an information base for formulating the different proposals contained herein. Thus the experiences of the persons interviewed, including those of the author's committee, and their interpretations of and opinions on those experiences will be used as the main documentation for advancing these proposals. Following are some of the criteria used to evaluate the significance and validity of the various opinions obtained in the interviews:

1. The opinions given concerning different aspects of the drainage programs studied were compared to the following (when such information was available):
 - a) number and severity of drainage complaints received from local citizens,

- b) extent of drainage problems in the area,
 - c) flood damages as related to the magnitude of historic storms in the areas studied,
 - d) problems encountered in the administration of the different aspects of the programs.
2. The consistency with which different aspects of the drainage program were reported by the persons interviewed (both within and outside the governmental unit being studied).
 3. When possible, the opinions given in the interviews were compared with available documentation (reports, Corps of Engineers Studies, U.S. Geological Survey Studies, planning reports and studies, etc.)
 4. Opinions from many people associated with different aspects of the drainage program were obtained and compared; including engineers, county and city personnel, developers, politicians, etc.
 5. Factors such as the following:
 - a) How long had the ordinance or regulation been in effect?
 - b) How often and what changes have been made in the ordinance or program?
 - c) The number and quality of personnel used in the administration of the program (quality was related to education, professional registration, and the author's impression from reviewing studies done by the individuals interviewed).

- d) How often had different aspects of the drainage program been used to solve or avoid drainage problems?

Thus the basis for the proposals and recommendations included herein are the experiences of the areas studied plus the author's experience. Throughout the thesis the author has made an effort to credit specific regulations or procedures used as the basis for the proposed model urban drainage ordinance.

Original Study Goals

An early step in structuring this study was to translate the general objective of collecting, evaluating, and organizing information for use in upgrading urban drainage practice into specific study goals (which were later revised). Following is a brief discussion of the four original study goals and how they were changed as the study progressed.

Develop Guidelines for Drainage and Erosion Control Ordinances

Soon after this study was started and contacts were made with city and county personnel, it became evident a model ordinance that could be readily adapted to fit local conditions would be more valuable than broad guidelines. The people interviewed expressed the opinion that an ordinance written from an objective position outside the internal pressures of the county or city would be most valuable. Thus, to make this thesis as useful as possible, guidelines were developed from the results of the case studies and then these guidelines were used to write the model urban drainage ordinance and accompanying commentary presented in Chapter IV.

Determine the Objectives of Local Governments in Regards to Drainage,
Erosion, and Flood Control

Only two jurisdictions studied had formulated written objectives specifically for drainage, erosion, and flood control. Many of those interviewed had not even considered the formulation of objectives and in some jurisdictions whatever objectives did exist had evolved through the years in unwritten form. When the ordinances and other aspects of the different drainage programs were formulated, there must have been some objectives. For some reason these objectives were not written down and through the years were forgotten or interpreted differently by the different persons interviewed. Often people with different interests will agree on a certain course of action to achieve a given result but will not agree on the specific objectives or reasons for supporting this action. This could account for the different interpretations and lack of written information on objectives.

In addition to stated objectives, drainage programs and ordinances include many inherent or inferred objectives. The author has attempted to document and use them in the subsequent discussions.

Determine Adequacy of Existing Ordinances in Meeting these Objectives

Since there was very little reliable data on objectives in most jurisdictions, the adequacy of the ordinances in meeting these objectives could not be evaluated except in general terms. Several of the areas studied had recently adopted their ordinance and thus have had little experience in its application and results. In the other areas there were no accurate records, such as the following, which could have

been used to document the effectiveness of adoption and implementation of the ordinance:

1. flood damages in quantitative terms before and/or after the adoption of the ordinance,
2. accurate maintenance records to determine changes in quantity or severity of maintenance problems after the adoption of the ordinance,
3. data to evaluate how the drainage system functioned during different storm events,
4. extent of compliance with ordinance,
5. hydrologic evaluation of ordinance,
6. community satisfaction.

Also hampering any evaluation of ordinance effectiveness was the fact that most drainage programs have been changed continually through the years with no accurate records to document changes. Thus, even if the above information had been available, it would have been difficult to correlate changes in drainage problems with specific changes in the drainage program. As a result much more approximate methods to evaluate ordinance adequacy and effectiveness had to be used than were anticipated during the formulation of this study. Hard data had to be replaced by personal opinions, broad interpretation of available documentation, general reactions of the persons interviewed, inferred objectives and information, etc.

Incorporate Technical Information in Drainage and Erosion Control Ordinances

The use of technical information in drainage programs was explored in the interviews and literature search. The results of this

inquiry were used as the basis for the discussions concerning the function of a Flood and Erosion Control Manual and the use of computer simulation in an overall drainage program. This goal remained unchanged as the study progressed.

Final Study Goals

As a result of the experiences indicated above, the following are the final study goals.

1. Develop a drainage ordinance based on the experience of the personnel within the areas studied, existing ordinances, author's personal experience, and current literature concerning urban drainage ordinances.
2. Investigate the use of technical information in drainage and erosion control ordinances.
3. Document the use of computer simulation in the DeKalb County Drainage Project and relate this work to the drainage ordinance from study goal (1) above.
4. Discuss in general terms the objectives and problems of urban drainage programs.

In order to present the logical order of how these study goals were pursued, this thesis is divided into six chapters. Following is a brief outline of the main content of these chapters.

Chapter I - Introduction

Chapter II - Hydrologic Computer Simulation in DeKalb County -

The analysis of urban drainage problems is becoming more complex and beyond the scope of those hydrologic techniques which have

become standard practice in most urban areas. Hydrologic computer simulation offers one means of dealing with these complex problems. Chapter II documents the use of hydrologic computer simulation in DeKalb County, Georgia. Since many of the recommendations included in subsequent chapters refer to the use of hydrologic computer simulation, it is necessary for the reader to become familiar with the general concepts involved.

Chapter III - Drafting a Drainage Ordinance - This chapter builds on the information on available hydrologic techniques to discuss some of the general considerations that a community should consider before they draft drainage regulations.

Chapter IV - An Urban Drainage Ordinance - Nineteen provisions of a model urban drainage ordinance are outlined and discussed in this chapter. The discussions include why these provisions should be included and how they relate to the different ordinances of the jurisdictions studied.

Chapter V - Formulating a Drainage Program - A discussion of administration of a drainage ordinance, technical aids required, and field inspection are included in this chapter.

Chapter VI - Conclusion - A summary of this survey and analysis of urban drainage ordinances is given which includes an evaluation of how well the study objectives were fulfilled and recommendations for communities anticipating using the results of this study.

The above organization of chapters was selected so that the reader would be familiar with certain concepts and procedures which are then used in subsequent discussions.

CHAPTER II

HYDROLOGIC COMPUTER SIMULATION IN DEKALB COUNTY

Problems involving hydrology have for years been analyzed by means of empiric methods or formulas, many of which date their origin back to the late 1800's. These methods employ the use of coefficients which attempt to account for many different aspects of the hydrologic cycle. Many of the engineers contacted in this study stated that these methods give conservative results and thus add a safety factor to the design process by oversizing drainage facilities. Although this may be true, today in many urban areas severe limitations are being placed on development in flood plain areas, the limits of which are being determined by these empirical methods or formulas; drainage structures are being sized to limit storm runoff, and oversizing these structures will limit their effectiveness; and the economics of drainage design are demanding more accurate and reliable hydrologic methods.

These empiric methods depend on the selection of a critical design storm which is used to estimate peak discharges and storm hydrographs. In estimating a design flood from a design storm, considerable judgment is required and unreliable results may be obtained. Today, with the use of digital computers, it is possible to utilize long periods of precipitation and runoff data to estimate flood peaks, flood hydrographs, low flows, etc. Thus, it is possible to continuously monitor the water balance within a watershed or several watersheds. In addition

the effects of urbanization can be quickly and accurately assessed by use of computer programming techniques.

Before a community drafts a drainage ordinance that will depend on advanced engineering techniques for its proper administration, they should consider what techniques are needed and available and their associated costs. Following is a description of a study being conducted in DeKalb County, Georgia, the purpose of which is to provide this County the technical tool necessary to adequately implement its drainage program.

Hydrologic Computer Simulation

In reviewing hydrologic methods presently being used by engineers, it becomes readily apparent that only portions of the hydrologic cycle are incorporated in these methods. Many components of the cycle and details of the drainage system are lumped together and represented by constants and one or two variables. Such procedures greatly simplify the computations but introduce broad assumptions which have not always been verified by scientific research and study. Recent hydrologic research has led to a method (hydrologic computer simulation) that accounts for the major components of the runoff process and allows a detailed description of the drainage system. This involves so many different calculations that a solution is physically impossible by conventional hand methods, but with the use of digital computers, solutions are possible and economical. The entire hydrologic cycle and the details of the drainage system can be simulated and alternative designs evaluated.

Hydrologic simulation is a numerical technique for conducting experiments on a digital computer. It involves certain types of mathematical and logical relationships (models) that describe the behavior of a hydrologic system over extended periods of real time. In other words, continuous digital simulation of a hydrologic system is the operation of a computer model which represents the essential features of the actual system being modeled.

A hydrologic model describes the response of a drainage area, composed of a network of interconnected stream channels and the adjacent land area that slopes downward toward those channels. In essence, a hydrologic model describes some or all of the components of the runoff process that are active in the drainage area. These include precipitation, evaporation, transpiration of plants, infiltration of water into the soil, drainage of storm water over the ground surface, movement of water down the stream channel system, and storage and detention of water on the ground surface, in the soil, in stream channels, and in lakes and reservoirs.

DeKalb County Study

The Georgia Institute of Technology contracted with DeKalb County, Georgia in 1974 to do a computer simulation study entitled, "Utilization of a Computer Model to Determine the Impact of Urban Development on Flooding in DeKalb County."

Dr. Alan Lumb, of the Georgia Tech School of Civil Engineering is the project director for this study and the materials discussed in this chapter were obtained from his project files and personal comments.

Study Objective

The objective of this study is to develop a hydrologic simulation model to determine the impact of urban development or potential development on downstream flooding in DeKalb County and evaluate measures to reduce the damaging impact.

Anticipated Benefits

Following is a discussion of some of the benefits that could result from the computer simulation study in DeKalb County.

County. The computer model from this study will be a unique and valuable tool for the County's drainage program. With the use of this model the following will be possible:

1. An accurate up-to-date flood plain map can be maintained to show continually the results of current development. Such maps can be a dynamic tool for County use in drainage planning rather than a static base like the existing flood plain reports. Also, by using the same model for any watershed in the entire County, consistency in procedures and methodology can be achieved.
2. The model will permit quick, economical, and accurate hydrologic evaluation of existing and proposed drainage structures and development within tributary areas. Thus it will be possible to assess accurately the effects of different designs for proposed drainage structures or changes in existing drainage structures.
3. The model can be used to evaluate the interrelationships between several developments and proposed drainage structures.

4. Alternate solutions to drainage problems can quickly and economically be evaluated.
5. Anticipated drainage requirements resulting from different land uses and configurations of development will be available for zoning and development decisions.
6. The effects of major floods on existing developments and structures within the flood plain can be determined and alternate solutions evaluated.
7. Since flood plain land is assessed, for tax and other purposes, at a much lower rate than other land it is to the County's advantage to accurately determine the limits of the flood plain, and changes in these limits, so that excess area is not designated as flood plain land. It is also possible that the results of the model will show that areas not considered as flood plain do lie within the limits of the flood plain.

Developers and Realtors. With the use of the model the following benefits to developers and realtors are possible:

1. If an accurate up-to-date flood plain map is available, a developer or realtor will be able to quickly assess how much of a proposed development will be located within the flood plain.
2. Developers will be encouraged to work with the County to evaluate potential drainage problems and alternate solutions. This encouragement will be fostered since the County will be able to provide answers quickly at minimal cost.

3. It is anticipated that the computer model will form a liaison between developers and the County to solve and/or prevent drainage problems within the County.
4. The model can relieve the developers of having to submit detailed flood plain studies for their proposed developments within the areas where the computer model is applied, but will require them to submit data on land use changes so the County will have better input when they run the model. The Federal Government and local lending institutions are very hesitant about supporting development within flood plain areas since passage of the Flood Disaster Protection Act of 1973. As a result developers now have to submit detailed studies to evaluate flood plain areas in order to finance developments. The cost of these studies can range from several hundred to thousands of dollars. This cost can be a financial burden to small developers.
5. With the cost of land in the Atlanta Metropolitan Area ranging from \$20,000/acre to over \$100,000/acre, it can be very costly to over estimate the limits of the flood plain.

Individual Citizen. With the use of the model the following benefits to individual citizens are possible:

1. When a citizen wants to develop a site for a private residence or small business, it becomes a significant financial burden for him to have to pay for an engineering study to determine the limits of the flood plain. With an up-to-date flood plain map, the citizen would only have to refer to this map for the needed information.

2. An up-to-date flood plain map would inform purchasers of land where the flood plain limits are. Thus, it would be less likely that unsuspecting purchasers would be sold flood plain land under the pretext it could be developed for other purposes. It is assumed the County will publish flood plain maps to make this information available to the public.

Model Calibration

The model being used in this study is general in nature and can be made to describe a wide range of hydrologic conditions and watershed characteristics. This model can be made to describe specific drainage areas by the correct selection of the values of parameters that occur in the mathematical expressions which make up the model. The selection of parameter values is referred to as "model calibration", and is one of the most important parts of the overall study.

Model calibration is an iterative procedure which involves (1) initial estimation of parameter values, (2) simulation of historical (previously measured and recorded) storm runoff events (floods), (3) comparison of simulated and measured floods, and (4) adjustment of parameter values to bring simulated floods in line with historical data. This process is repeated until the model is capable of reproducing the historical events.

Model calibration is based on the records of rainfall and runoff from historical events that have occurred in DeKalb County and in the immediately surrounding areas. Some records currently being collected in the metropolitan area by the U.S. Geological Survey are available. Moreover, additional gaging sites will be instrumented. Currently there

are no gages located on small watersheds (less than 200 acres). Collection of data from small watersheds is necessary if runoff from these watersheds is to be reliably modeled. Also there are no data currently available from the southeast portion of the county. Rainfall and runoff data from this area are needed for modeling in this part of the County.

Scale of Simulation

Conducting hydrologic simulation studies requires, for practical reasons, two scales of activities. The practical reasons relate to computer capabilities and personnel available for data collection and coding data for input to the computer. Greater computer capability and greater detail in input data increase accuracies in predicting stream elevations during floods. However, beyond some point the benefits of additional accuracy cannot justify the funds required for computer time and added personnel. Dr. Lumb feels that the simulation study described herein adequately balances the trade-offs between greater accuracy and larger budgets. This balance is also a function of population density and most of the areas included in this study are of U.S. metropolitan suburbia.

Large Scale Simulation. Large scale simulation is for drainage areas greater than approximately 100 acres or drainage areas which produce 100-year floods greater than 500 cfs in DeKalb County. Large scale simulation can be used for determining:

1. downstream flooding levels,
2. flooding effects of zoning policies for undeveloped lands,
3. size of dams for flood reduction,

4. use of existing lakes for flood control,
5. effect of debris removal on upstream and downstream flooding,
6. effect of sewer pipe relocation,
7. effect of culvert enlargement on upstream and downstream flooding,
8. effects of upstream detention structures,
9. 50-year and 100-year flood plain elevations before and after development,
10. effects of other policies or structural measures the planners, engineers, elected officials, or private citizens may envision.

Although a general computer program for storm runoff computations is used for large scale simulation, the input data on land characteristics, stream channel characteristics, and storm characteristics are unique to each separate drainage area. Thus, each drainage area studied requires field surveys, preliminary analysis of the data obtained, and coding and keypunching the data for use in the computer.

Small Scale Simulation. Small scale simulation is for drainage areas less than approximately 100 acres and generating 100-year floods less than 500 cfs in DeKalb County. Small scale simulation studies can be used for design of:

1. retention basins for storage of excess runoff from residential, apartment, industrial or commercial development,
2. measures such as spreading excess runoff over previous pavement for parking lots, underground storage in tanks or aquifers,

3. culverts, and
4. analysis of flooding effects immediately downstream from the proposed development under different assumed drainage plans.

As with large scale simulation, a general computer program for storm runoff computations is used, and detailed input data for each development site is required.

The model used in the DeKalb Study has been used to simulate flows for both large and small drainage areas although no applications of small scale simulation will be included in this study.

Continuous and Storm Period Simulation

A further dichotomy of hydrologic simulation involves continuous simulation and storm period simulation. The distinction between the two is simply the time period for which the simulation is conducted. Continuous simulation involves calculation of simulated flow for every day or hour for a period of several months or many years. Storm period simulation involves calculation of simulated flows every few minutes for several hours or a few days.

Continuous simulation is used to develop runoff files for DeKalb County which incorporate the effects that time of year, soil moisture, and rainfall intensity have on runoff volumes from a particular soil type. The U.S. Soil Conservation Service has divided soils, with respect to infiltration rates, into four hydrologic soil groups. Three of these groups are found in DeKalb County. Simulation is used to develop runoff files for each of these three groups plus one for impervious area. These runoff files represent the runoff expected from a unit area of a particular soil type or impervious area without taking

into account channel flow. By combining the proper percentages of these four runoff files, runoff from the land surface of the watershed under investigation is determined.

Runoff values from continuous simulation for selected storms and the division of the land surface among soil types and impervious area are then used as input data to storm period simulation. Storm runoff generated from the runoff files is then routed through the channel system (including storage facilities) to determine resulting channel flows. Analysis of drainage problems and evaluations of potential solutions is accomplished with several storm period simulations each year for 25 years. Continuous simulation only needs to be performed once to generate the runoff file necessary for storm period simulation.

County's Use of Simulation Model

The simulation model to be developed for DeKalb County will allow:

1. identification of flood plain elevations for all streams,
2. prediction of the effects of future urbanization of the flood plains at many key points along the streams,
3. estimation of peak flows and water levels (stage) for various frequencies with and without flow regulating facilities,
4. performance of operation studies for larger detention storage facilities,
5. identification of channel constrictions which presently increase upstream flooding, and identification of those channel constrictions expected to affect flooding at some future date when undeveloped upstream areas become more fully developed.

Continuation of Study by DeKalb County

Following the completion of this study by Georgia Tech, DeKalb County will have to assume several areas of responsibility in order to effectively utilize the study results.

1. The County will need to employ a small staff qualified in the use and application of the computer model. Even though there will be an operating manual on the use of the model these personnel will need specialized training and experience to fully utilize the capabilities of the model.
2. A comprehensive rain and stream gage network is an important part of the original study and will be continued by the County to provide additional data for future model calibrations.
3. A continuous working relationship with the personnel who conducted the study would be valuable to the County in order to keep the computer model up-to-date. With such a relationship the County could also benefit from counsel outside the governmental structure on application of the model to specific problems.
4. The County must decide whether to use its own computer facilities or purchase time on a computer system. Most county and city computer systems are oriented toward administrative rather than scientific applications. Dr. Lumb feels that if several Atlanta Metropolitan Counties used the same computer model, a commercial computer system oriented toward scientific applications could be used by all counties. In Dr. Lumb's

opinion, this would be more efficient than each county using its own system.

5. Dr. Lumb estimates that it will cost the County from \$7,000 - \$10,000/year to maintain the computer model, handle difficult application problems and pay for the needed computer time, although this figure could vary considerably depending on the amount of use the model gets.
6. The study undertaken by Georgia Tech will only involve getting data on a few watersheds. If the County wants to use the simulation program throughout the County they will need to get data on the remaining watersheds. This will be a fairly large task. No cost estimates of completing such a task had been made at the time this thesis was written.

Implications of DeKalb's Study for Other Areas

DeKalb County has invested approximately \$100,000 in the hydrologic computer simulations study just discussed. In addition, the County will need to invest additional funds to complete the study for the entire County and keep it in use and up-to-date. Whether or not this initial cost is justified will largely depend on the amount of use the simulation model gets. DeKalb County personnel anticipate the simulation model will receive extensive use since:

1. there are many existing drainage problems in the County which will need to be analyzed,
2. some areas of the County are presently being developed and these areas will need to be analyzed to prevent future drainage problems,

3. DeKalb County has adopted a drainage ordinance which will necessitate the use of advanced engineering techniques for design of storage facilities and evaluation of different development alternatives.

With the completion of the study DeKalb County personnel will have the technical tool necessary to adequately implement their drainage program. It should be pointed out that in contrast to the large initial costs, the County will be able to quickly analysis different development and design alternatives for a relatively small cost per application. Neglecting the initial development costs, use of the simulation model should be less expensive than conventional engineering methods and for complex problems the savings should be considerable.

Thus, this study has several implications for areas that are considering the use of hydrologic computer simulation.

1. If an area intends to adopt a drainage ordinance which will need advanced engineering techniques for its administration, the development of some hydrologic simulation model should be considered.
2. Since there is a high initial cost for developing a hydrologic simulation model, it might be wise to combine several political entities or develop a metropolitan or regional district and have several governments share the cost of developing the model.
3. For small cities and counties it might be preferable to use the services of a consulting firm rather than having city or county personnel operate the model.

4. If an area anticipates the use of hydrologic simulation in the future, thought should be given to establishing a stream and rain gaging system as soon as possible so that the needed hydrologic data will be available.

CHAPTER III

DRAFTING A DRAINAGE ORDINANCE

Before any community drafts and adopts a drainage ordinance several general considerations should first be reviewed. The community should identify the problem areas which the ordinance will attempt to deal with. Some basic decisions should be made concerning the communities philosophy for dealing with drainage problems. The general format of the drainage ordinance is another consideration that should be dealt with. These are some of the areas that will be discussed in this chapter.

In order to clarify the use of several terms used in this thesis the following diagram and discussion is included.

Problem Areas → Objectives → (Policy Statement) → Control Manual

Drainage Ordinance Flood and Erosion

Problem Areas - these are the problem areas which will be considered and dealt with in the ordinance and drainage program.

Objectives - these are the objectives of the ordinance and drainage program and represent the community's philosophy for dealing with the problem areas. These objectives could also be considered the goals of the ordinance and drainage program.

Drainage Ordinance - general policy statement concerning drainage and flood control.

Flood and Erosion Control Manual - engineering manual dealing with the engineering and technical details associated with the policies contained in the ordinance.

In the above diagram there should be feedback and interaction between the elements described in order to provide a continual evaluation of the county's drainage program.

Drainage Objectives

As discussed in the introduction, two of the original goals of this study were:

1. to determine the objectives of local governments in the areas of drainage, erosion, and flood control,
2. and to assess the adequacy of existing ordinances in meeting these objectives.

As the interviews with city and county personnel progressed, it quickly became evident that very little consideration had been given to stating objectives for their drainage program, keeping up-to-date the original objectives of the drainage program (if determined), or evaluating the adequacy of the existing drainage programs. Many of those interviewed gave what they considered to be some objectives of their drainage programs but also stated this represented their opinion and not an official position of the county or city.

In many areas those who took the leadership in getting the ordinances and regulations adopted had either left the area, died, terminated their employment with the agency, or for some other reason were not available for comment. Thus, it was difficult to assess these two study goals except for the fact that objectives had not played a significant part in the execution of existing ordinances.

In contrast to what was done, when the subject of objectives was brought up during the interviews, both technical and nontechnical

personnel felt the establishment of a definite set of objectives is not only important but should be the first step in formulating a drainage program.

Furthermore, many of those interviewed felt that a continuous evaluation of the drainage program should be done to determine whether the program is carrying out the objectives (and how effectively), and whether the objectives should be modified or changed. Thus objectives should be used to give direction and feedback to the drainage program.

It is also important that all drainage personnel be informed as to what the objectives are and when changes in the objectives are made. This information should be published and promulgated by the county. In many localities, personnel within the city or county government as well as outside consultants, complained they did not know about several aspects of the total program and were not kept informed about program changes. One means of keeping everyone up-to-date would be for the county to publish a newsletter when changes are made in the drainage program.

Numerous elected officials were contacted and their opinions, relating to different aspects of their local drainage program were obtained. The questions pertaining to stated goals and objectives yielded interesting answers. Everyone felt goals and objectives were essential. They felt goals help evaluate long-term planning, help interpret regulations and ordinances, and give direction to the drainage program.

Some elected officials felt goals should be written into the ordinance while others felt they should be contained in another document such as a general plan or resolution. Others felt goals were inherent

in any document and need not be written separately. The politicians did not offer any specific goals but several stated that the goals should be specific and simply stated in contrast to some of the general and elaborate goals contained in many planning documents.

Most of the politicians did not see any particular problems in arriving at stated goals and objectives for their drainage programs. Their general opinion was that some goals and objectives were essential. They could not give specific reasoning why their present drainage program existed without some stated goals and objectives.

It is concluded that without properly defined objectives (both known to the people involved in the drainage program and actually representing the consensus of opinion as to what the objectives should be) the major effort of the personnel involved with the program is with the day-to-day problems and their immediate solutions (this may be a valid objective of the program but it should be stated as such). Little if any time is given to any of the following important aspects of the program, which would have an impact on long range and immediate problems:

1. long range implications of present actions,
2. direction and scope of present drainage program,
3. effectiveness of present drainage program,
4. changes that should be made in present program,
5. what is being accomplished by the present program and what the city or county wants to accomplish.

When questions about these points were brought up in the interviews, no one was able to give data to support an answer one way or another. As a result, only personal opinions were obtained.

It should be pointed out that having stated objectives will not guarantee that the above aspects will receive proper consideration, but should at least bring some of these aspects to the attention of the policy makers and those implementing the drainage program.

Thus, while the drainage personnel felt some work toward establishing objectives was important, little in reality has been done in this area. This points to the importance of stated rather than inherent objectives. Stated objectives would enhance consistency in any evaluations of different aspects of the program and would also document changes. Stating the objectives would lessen the chance of misinterpretations and forgetting what the objectives are.

Drainage Concerns

Before any of the aspects of an urban drainage program (ordinances, standards, engineering documents, etc.) are considered, the general drainage concerns that will be dealt with should be determined. Selection of these concerns will define in general terms the scope and extent of the drainage program.

Although each city or county should determine its own concerns to be dealt with in its drainage program, the following were considered in drafting the drainage ordinance discussed in chapter IV.

1. Flood Control
2. Erosion and Sediment Control
3. Economic Efficiency in Drainage Design and Flood Control
4. Insure the Use of Good Engineering Practices
5. Protection for Present and Future Development Given Certain Design Constraints

6. Equity in Drainage Design and Implementation
7. Control Development within the Flood Plain
8. Provide Controls for the Installation of Drainage Systems
9. Maintenance

It is up to the local governing body to determine which of these areas they want to include in their drainage program and then to formulate objectives within these and any other additional areas.

Drainage Ordinance-A Policy Statement

The drainage ordinance must be officially adopted by a governing body before it can be legally applied. As a result, the political process becomes the controlling force behind such a document. Therefore, it should be designed so that it can be understood by elected officials and aid them in the execution of their responsibilities.

Elected officials should not be dealing with engineering criteria or design standards. Also most elected officials are not administrators and should not be particularly concerned with the administrative aspects of a drainage program except as these aspects relate to budget control. Elected officials should determine the overall policies within their jurisdiction. Thus, to make the drainage ordinance a viable part of the political process, it should serve as a policy statement for the county or city. Technical details of the drainage program should be included elsewhere.

Some administrators prefer laws which are very detailed and try to cover all problems that may arise in administration of an ordinance. In addition, they tend to include engineering criteria and design standards in order to encourage uniformity. The administrators dealing with

the public feel they can be more firm in enforcing the provisions of an ordinance if written into law. It is contended, if many members of the public (or a few influential ones) complain to elected officials, these officials may find it easier to use their political pressure to allow exceptions if a point is not written into law.

As proposed, the urban drainage ordinance would be limited to stating specific policies. Engineering criteria and technical details would be contained in other documents in order to fully discuss these criteria and details and keep them up-to-date. Elected officials could then refer technical questions to the County Engineering Department and spend more time and effort dealing with policy matters. In order to prevent the Engineering Department from becoming completely autonomous from public and political influence, engineering documents should be subject to the approval of elected officials, without formally being enacted into law. This would encourage some uniformity and give administrators a ready reference for dealing with problems and combating political pressures to make exceptions.

Following are some examples of policies that should be dealt with in an urban drainage ordinance.

- a. Should flood protection be provided for frequent events (say, less than 10-year storms) or should protection against rare events (say, 50 or 100-year floods) be provided?
- b. Should flood protection be provided only in large drainage areas or small ones also, and if so, how small?
- c. Should the intent of the drainage program be to pass flooding problems downstream or should measures be used to lessen or at least not increase flooding downstream?

- d. Should the regulations and standards of a drainage program vary from one part of the community to another?
- e. Is the county or city going to maintain the entire drainage system or just certain segments?
- f. Should retention or detention facilities be centralized or decentralized, publically owned or privately owned?
- g. What restrictions should be placed on development within the flood plains?
- h. What erosion control practices, if any, should be adopted?

In the communities studied, the above point of view was not followed in drafting many of the existing drainage ordinances. Many of these ordinances evolved through the years and have become complex documents dealing with many details of the drainage program. In addition, these ordinances have dealt with engineering criteria and design standards.

One standard question asked in each area studied was how design standards had originated. Almost universally the answer was that they did not know (usually because the decisions were made many years ago) or that the standards had evolved from political or administrative compromise rather than having some sound technical basis.

When the idea of using the drainage ordinance as a policy statement was presented, the overall reaction was favorable. The following comments encompass the general feelings of those interviewed.

- 1. Such an ordinance would clearly indicate the policies of the government concerning drainage. Many of the existing ordinances try to deal with so much material that they become very complex and difficult to understand.

2. By using the ordinance as a policy statement, all engineering and design criteria and specifications could be contained in other documents and continually updated without changing the ordinance (specific controls could be put on these documents).
3. Such an ordinance would allow both the political process and the technical process to be used efficiently within its major area of concern.

As a result of these comments, the model ordinance presented here is written in terms of a policy statement. It does not deal directly with specific technical aspects of an overall drainage program.

Flood and Erosion Control Manual

In formulating a drainage program, writing the drainage ordinance would precede the writing of any accompanying technical or engineering documents, so that these latter documents will reflect the technical and engineering requirements needed to administer the ordinance. To avoid possible confusion when reading the proposed model drainage ordinance the following outline and discussion of a Flood and Erosion Control Manual is included to give the reader a general knowledge of the content and scope of such a document.

Following is an outline of topics that could be included in such a manual. This list is intended to give examples, not to be all inclusive.

- Engineering Design Criteria and Standards
 - Design Storms (if used)
 - Flood Plain Reports
 - Flood Maps (Flood Maps, Soil Maps, etc.)
 - Drainage Easement Criteria

Grading and Drainage Plans

- Information to be Shown on Plans
- Data Required
- General Format
- Special Requirement for Small Areas

Hydrologic Design

- Design Standards for Small Areas
- Design Standards for Large Areas
- Retention and Detention Design

Flood Plain

- Method and Guidelines for Calculations
- Water Surface Calculations
- Effects of Filling and Excavating in the Flood Plain

Closed Conduit System

- Energy and Hydraulic Gradients
- Closed Conduit Design Calculations

Open Channel System

- Channel Size and Shape
- Channel Materials
- Energy and Hydraulic Gradients
- Channel Design Calculations
- Energy Dissipation

Storm Sewer Appurtenances

- Curb Inlets
- Grate Inlets
- Yard Inlets
- Manholes
- Energy Dissipators
- Inlet Design Calculations

Determination of Culvert Sizes

- Inlet Control
- Outlet Control
- Barrel Control
- Culverts in Series

Erosion and Sediment Control

- Seeding and Planting for Erosion Control
- Mulching
- Specific Practices for Local Application
 - Protection of Storm Sewer Inlets
 - Diversion and Berms
 - Straw Bale Barriers
 - Other Means
- Silt Basin Design
- Sample Erosion and Siltation Control Plans
- Grading Practice

Cost Allocation of Drainage Improvements

- On-Site Improvements
- Off-Site Improvements
- Combined Facilities

Maintenance and Operation

- Present Maintenance Programs
- Roles of Governments and Owners

Flood-Proofing

- Types of Flood-Proofing
- Engineering Aspects
- Flood-Proofing Operations

This manual would not be officially adopted into law by a government entity but could be subject to its approval and would be kept in a form such that it could be continually updated and changed to conform to the latest county or city procedures. Fairfax County has used this procedure with their Erosion-Siltation Control Handbook (12). The Denver Urban Storm Drainage Manual is contained in loose-leaf notebooks so that it can be easily updated, hopefully with dated pages (55). Following is a quotation from this manual which further emphasizes the need for updating such a manual.

A compilation of engineering criteria such as the Urban Drainage Criteria Manual is a dynamic rather than static volume and needs to be reviewed and updated to keep it abreast of developments in the important and rapidly expanding field of urban storm drainage. It is the intent of those responsible for the conception and development of the Manual to periodically issue revisions to the Manual which incorporate new data, methods or criteria and such other information as may be deemed appropriate.

The major thrust of the Flood and Erosion Control Manual is to present examples in such detail that a design engineer can determine generally what is expected by the county in different drainage and erosion control designs. The manual should not be a limiting document forcing the engineer to use standard designs and procedures. Several design

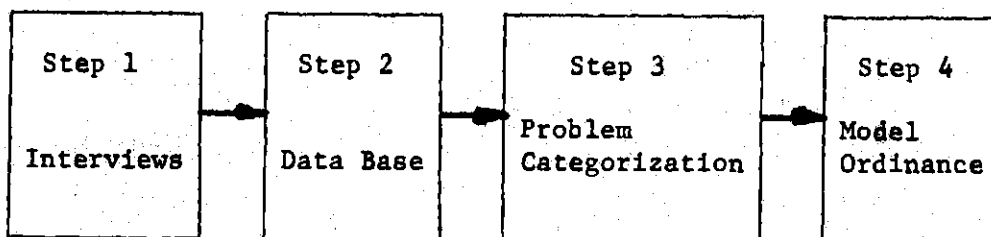
examples should be given (and references of additional design criteria cited) with latitude for the design engineer to use his imagination and engineering judgment. The manual should have the connotation of a document that suggests and informs rather than limiting or prescribing. In addition, the manual would give more complete definitions of some of the concepts included in the ordinance, than was possible in the definitions section of the ordinance. In the following chapters (especially Chapter IV) numerous references are made to the types of information that should be contained in a Flood and Erosion Control Manual rather than within the drainage ordinance.

The County Engineering Department should be entrusted with the responsibility of keeping the Flood and Erosion Control Manual up-to-date. Periodic reviews of this document should be made (say, every year or when major changes in the manual occur) by elected officials or a special committee selected for this purpose. This would enable the elected officials to be kept informed of changes which might affect stated policies and objectives, and also provide a check to ensure a sound basis for a given update. If needed, elected officials or committee members could obtain outside opinions on engineering and technical matters to augment those provided by the County Engineering Department.

CHAPTER IV

MODEL URBAN DRAINAGE ORDINANCE

The major objective of this study of urban drainage programs is to utilize the findings and experiences that several urban areas have had with their drainage programs in order to draft a model drainage ordinance that could be used with minor modifications to fit local conditions by both urbanized and urbanizing areas. The following diagram shows the steps that were used in drafting this ordinance.



Step 1 - Interviews with County and City employees, engineers, elected officials, and others involved in local drainage

Step 2 - Review of the publications pertaining to drainage obtained from the persons interviewed and of other pertinent material (including technical literature, existing ordinances, and information available on the computer simulation study in DeKalb County, Georgia)

Step 3 - Compilation of the information into suitable problem categories for use in drafting a model urban drainage ordinance

Step 4 - Preparation of the model urban drainage ordinance

The introduction and first two chapters discussed the first two steps. The Problem Categorization in Step 3 involved organizing the information on problem areas obtained through the interviews, the

technical guidance provided by the data base and the provisions of existing ordinances into general categories to be covered by the model ordinance such as flood plain district uses, improvements required and maintenance. The grouped information was then used to formulate the section of the ordinance for dealing with the problem as follows:

1. All ordinance provisions within a category were compared to identify similar approaches and contradictions.
2. The technical information and problem descriptions were then reviewed in order to assess the adequacy of the existing ordinances and establish points on which changes are needed.
3. The provisions of the model ordinance were then drafted using provisions from the ordinances studied plus information from the interviews and the data base. The model ordinance is presented in this chapter, and each section is followed with a discussion of its provisions.

Many of the provisions in the model ordinance are based on several ordinances and thus no particular ordinance is directly referenced. The commentary following each provision references the communities having regulations similar to those in the model ordinance.

Much of the information used to document why particular provisions and concepts were included in a specific ordinance or drainage program was obtained from personal interviews. Many times the person interviewed gave comments about his particular program or drainage ordinance that must be treated as confidential, and thus reference to particular individuals is usually not included in this thesis. Reference in this chapter will be made to the city or county personnel and not to

particular individuals.

The model urban drainage ordinance is divided into 19 sections. Each section contains one or more related provisions followed by a commentary which documents why the provisions are included and how they relate to the practices in the areas studied. In the following chapter, the provisions are given in italics to aid the reader in distinguishing provisions of the ordinance from the commentary.

During the ensuing sections of this chapter the terms County Engineering Department and County Engineer will be used. If a Public Works Department, Roads and Drainage Department, Community Development Department or some other agency will have the primary responsibility of enforcing this ordinance, the appropriate terms should be substituted for those used in this text. The ordinance is written for use by any type of local government (county, city, village, etc.), but to be consistent with the above terms, the word County will be used to represent the different types of local governments.

Except for Sections 4.0, 5.0, 6.0, and 7.0 of the following ordinance, the provisions of this ordinance apply to all development within the County's jurisdiction. Sections 4.0 - 7.0 apply only to development within the designated flood plain district. It will be noted throughout the ordinance that many provisions refer to a development permit. This permit is issued by the County and is needed to proceed with any development operations within the County's jurisdiction (including clearing, grubbing, grading, filling, excavation, or any other development operations).

Section 1.0 - Scope

This ordinance amends and supplements the following ordinances:

1. Subdivision Ordinance (Title),
2. Zoning Ordinance (Title),
3. Building Construction Ordinance (Title),
4. Any other ordinance related to the proposed drainage ordinance.

Commentary

Section 1.0 - Scope. This ordinance should be designed to complement and supplement, rather than conflict and overlap with existing ordinances. Thus the interrelationships between this ordinance and existing ordinances are important and reference to these ordinances should be included in this ordinance. Section 1.0 lists typical ordinances that may exist. This is consistent with most of the ordinances studied.

Section 2.0 - Definitions

For the purpose of this ordinance, the following definitions shall apply:

- 2.01 Channel - a natural or artificial watercourse of perceptible extent, with a definite bed and banks to confine and conduct continuously or periodically flowing water. Channel flow thus is that water which is flowing within the limits of the defined channel.
- 2.02 Detention Storage - storm runoff collected and stored for a short period of time and then released at a rate much less than the inflow rate.

- 2.03 Developer - any person who acts in his own behalf or as the agent or an owner of property and engages in alteration of land or vegetation in preparation for construction activity.
- 2.04 Development - any action in preparation for construction activity which results in an alteration of either land or vegetation.
- 2.05 Development Permit - permit issued by the County which is needed before any development operations can be started (including clearing, grubbing, grading, filling, excavation, or any other development operations).
- 2.06 Drainage - a general term applied to the removal of surface or subsurface water from a given area either by gravity or by pumping, commonly applied herein to surface water.
- 2.07 Drainage System - the surface and subsurface system for the removal of water from the land, including both the natural elements of streams, marshes, swales and ponds, whether of an intermittent or continuous nature, and man-made elements which include culverts, ditches, channels, storage facilities, and the storm sewer system.
- 2.08 Erosion - the general process whereby soils are moved by flowing surface or subsurface water.

- 2.09 Flood - a temporary rise in the level of rivers, streams, watercourses, and lakes which results in inundation of areas not ordinarily covered by water.
- 2.10 100-Year Flood - a flood which has the probability of occurring once every 100 years or having a one (1) percent chance of occurring each year.
- 2.11 Flood Plain - the land adjacent to a body of water which has been or may be covered by flood water including but not limited to the 100-year flood.
- 2.12 Flood Plain District - land use district, designated by the County, which is enclosed within and bounded by the limits of the 100-year flood contour elevation.
- 2.13 Flood-Proofing - a combination of structural provisions, changes, or adjustments to properties and structures subject to flooding primarily for the reduction or elimination of flood damages to properties, water and sanitary facilities, structures, and contents of buildings.
- 2.14 Hydrologic and Hydraulic Study - engineering study to determine rates, volumes, and distribution of storm runoff.
- 2.15 Retention Storage - storm runoff collected and stored for a significant period of time, and released after the storm runoff has ended.

Retention storage is often associated with "wet reservoirs" which have special recreational or aesthetic uses centered around a minimum pool.

- 2.16 Storage Facility Study - engineering study to determine if retention and/or detention storage facilities are needed to control storm runoff from a development.
- 2.17 Obstruction - any dam, wall, wharf, embankment, levee, dike, pile, abutment, projection, excavation, channel rectification, bridge, conduit, culvert, building, wire, fence, rock, gravel, refuse, fill, structure, or matter in, along, across, or projecting into any channel, watercourse, or flood plain area which may impede, retard, or change the direction of the flow of water, either in itself or by catching or collecting debris carried by such water, or that is placed where the flow of water might carry the same downstream to the damage of life or property.
- 2.18 Sedimentation - The processes that operate at or near the surface of the ground to deposit soils, debris, and other materials either on other ground surfaces or in water channels.

Commentary

Section 2.0 - Definitions. These definitions are included to clarify some of the terms and concepts used in the different sections

of this model urban drainage ordinance. A more complete definition and discussion (including illustrations and examples) of many of these terms and concepts are given in the County's Flood and Erosion Control Manual. Most of the ordinances studied included a definitions section similar to Section 2.0 of this model ordinance.

Section 3.0 - Statement of Objectives

- 3.01 Protect human life and health
- 3.02 Minimize public and private property damage resulting from erosion, sedimentation and flooding.
- 3.03 Regulate use of flood plains for development, fill, dumping, storage of materials, structures, buildings, utilities, or any other work which acting alone or in combination with other existing or future uses will increase flood heights and velocities, upstream or downstream from proposed use, by obstructing flows and reducing valley storage.
- 3.04 Regulate development which may, when acting alone or in combination with similar developments, create a demand for public investment in flood-control works by requiring protection against flood damage at the time of initial construction and afterwards.
- 3.05 Ensure, as far as possible, an efficient drainage system that will not result in excessive public or private moneys being used for maintenance and

- replacement of portions of the system.
- 3.06 Ensure that the design of the drainage system will be consistent with good engineering practice and design.
 - 3.07 Provide temporary and permanent erosion and sediment control measures to protect individuals occupying land adjacent to and downstream from proposed developments from being damaged by sediment originating from within or because of the proposed development.
 - 3.08 Control flood plain uses to be consistent with approved land use plans for the flood plain areas and coordinated with plans for the total community.
 - 3.09 Provide for development of areas with minimum adverse effects to the natural environment.
 - 3.10 Encourage wise use of the County's economic and fiscal resources.
 - 3.11 Discourage development in areas subject to flooding problems.
 - 3.12 Encourage economical uses and designs in flood plain areas.
 - 3.13 Provide a means of placing potential owners, builders, developers, and the general public on notice of potential flood hazards.
 - 3.14 Utilize existing channel capacity for flood flows before using on-site storage or other structural measures.

- 3.15 Utilize appropriate public open space for both open space uses (parks, recreational uses, etc.) and the temporary storage of excess storm waters.
- 3.16 Keep the drainage system as natural and aesthetically pleasing as possible.
- 3.17 Develop a comprehensive drainage plan for the area to handle storm runoff safely and efficiently.
- 3.18 Provide for public awareness of the flooding potential.

Commentary

Section 3.0 - Statement of Objectives. Although all of the above objectives were included or implied in the drainage programs of one or more of the areas studied, only one area had specifically and clearly listed the objectives of their drainage program. The objectives of the other areas were scattered through several ordinances and/or publications, or were not in written form but were expressed and identified as objectives during the interviews. Thus there is no guarantee that these objectives had been given careful consideration or that they could be considered representative of the County's objectives in their drainage program.

Of the areas studied only two had included, in one form or another, eleven or more of the above objectives in their program. Four of the areas had included six or more, while two areas had no stated or implied objectives for their drainage program.

Except for DeKalb County, all of the areas studied had started their drainage programs by proposing and enacting ordinances and

regulations without first stating any specific objectives for the programs. Several of the people interviewed, in each of the areas studied, indicated that logically the formulation of objectives should be one of the first steps in developing a drainage program. This may have been done at the inception of the different drainage programs studied, but for one reason or another, there was no written information to document many of these objectives.

The usual reasons given for not having objectives were one or more of the following:

1. the drainage program has evolved through the years with little thought to short or long term objectives,
2. there was an immediate need for an ordinance or regulation and not time to evaluate or determine specific objectives,
3. there had been no thought given to determining objectives,
4. although there was general agreement on adopting an ordinance there was not agreement on the objectives or reasons for supporting it and thus a list of specific objectives was not formally adopted or even drawn up. Sometimes this is a good reason for not having objectives. If general agreement on objectives cannot be obtained and this prevents adoption of drainage ordinance, it might be best to leave objectives out of the drainage program. After the ordinance has been in effect for a period of time,

it might then be easier to gain acceptance of some objectives,

5. The original objectives, when the ordinance was adopted, had been forgotten through the years without any thought given to keeping a record of them or documenting changes. It was just assumed that everyone realized what the objectives were.

A detailed specification of objectives is a necessary part of any drainage program and serves several important functions:

1. promotes public understanding of the objectives of the ordinance and drainage program,
2. promotes judicial understanding of the objectives of the ordinance,
3. serves as a check list to determine whether or not the ordinance covers all of the areas the city or county wishes to include,
4. outlines the direction and scope of the drainage program,
5. serves as a means to evaluate the effectiveness of the ordinance and drainage program.

When objectives were discussed in the interviews, there was agreement that some objectives should be included in a drainage program. Thus, it is difficult to understand why objectives, which seem in this study to be universally accepted as an integral part of any drainage ordinance and/or program, were not included in so many of the ordinances studied. The interviews clearly indicated that the persons involved with drainage

programs felt specific objectives were important even if their program had none.

It should be remembered that specific objectives adopted for any area should be tailored to fit local conditions and the local drainage program. The list of objectives given in this section, gives examples of typical objectives which might be included in an urban drainage ordinance. Local areas may want to delete or add to this list.

Section 4.0 - Establishment of Flood Plain District

4.1 Lands to which this Section applies - All of that area inside the 100-year flood contour elevations along streams or other drainageways draining five acres or more is classified as being within a flood plain district.

Commentary

Section 4.1 - Lands to which this Section Applies. This section sets up a single flood plain district based on the 100-year flood. In contrast to this approach, Ingham County uses two districts, a floodway and a flood fringe, to define their flood plain. They define a floodway as, "the channel of a stream and those portions of the flood plain adjoining the channel that are required to carry and discharge the flood water or flood flows of any river or stream including but not limited to flood flows associated with the intermediate regional flood. A flood fringe is that portion of the flood plain outside the floodway." Although the use of these two districts is also encouraged in some of the literature concerning flood plain delineation, it was found in this study that in many areas sufficient data is not available to accurately define

two districts. It was also brought out in the interviews that many people do not feel there is a need for more than one district and that two districts might be harder to administer and confusing to engineers and developers. For these reasons, a single flood plain district is used as the basis for this ordinance.

The Federal Insurance Administration is proposing to do flood plain studies in conjunction with the Federal Flood Insurance Program. In these studies a "floodway" and "flood-fringe" will be delineated. The floodway will be designed to carry the deep and fast-moving waters while the flood fringe will usually contain shallow and slow-moving waters. In many communities, these studies will not be completed for several years. In order to adopt an ordinance now, it will be much easier for these communities to use the single flood plain district described above. As these FIA studies become available communities participating in the flood insurance program will be required to change their drainage ordinance to implement them. The following changes in the proposed model urban drainage ordinance will be necessary to comply with FIA requirements:

1. Section 4.0 - This section will have to be changed so that a Floodway District and Flood-Fringe District are used instead of a single Flood Plain District. The limits of these districts will be defined in the FIA studies.
2. Section 5.0 - Change the wording from Flood Plain District to Floodway District.
3. Add a section dealing with Flood-Fringe District uses. This section should describe uses allowed in the Flood-Fringe

District in addition to those allowed in the Floodway District. This section should also contain provisions for special-permit uses within the Flood-Fringe District.

4. Section 8.0 - The FIA studies would be used to establish the Floodway and Flood-Fringe Districts and thus other hydrologic and hydraulic studies would not be needed to delineate flood plain areas.

Although any design flood can be used as the basis for the determination of a flood plain (25, 50 and 100-year design floods were used in the different areas studied) the use of the 100-year flood is becoming a standard practice throughout the country. One reason is that the Federal Government's Flood Insurance Program is based on the 100-year flood. Also, the U.S. Army Corps of Engineers Flood Plain Information reports are based on the intermediate regional flood (100-year flood). Several of the areas studied that had recently used a design flood other than the 100-year flood (Fulton County, Fairfax County, Atlanta and Tampa) are now changing to the 100-year flood or are planning to in the future. In addition (Tampa, Chicago) have used historical peak flows to delineate their flood plains. Using historical peak flows presents problems since the indicated flood plains over the entire area under consideration will not necessarily be based on the same severity of flood. Also, since the return period of the storm is usually not known, the probability of flooding the areas adjacent to such a flood plain is not known.

The other major source of flood plain information used by several areas was Soil Conservation Service Soil Maps indicating alluvial deposits. The use of these maps is very popular in those sections of the

Atlanta Metropolitan Area where hydrologic and hydraulic studies are not available. These maps have found their greatest use as a rough indication of the limits of the flood plain, as indicated by soil deposits. After establishing that the soil deposits indicate the presence of a flood plain, a detailed engineering study is done to determine the evaluation of the 100-year flood.

A report by Dale E. Parker, Gerhard B. Lee, and Douglas A. Yanggen entitled, "Using Soil Maps to Delineate Floodplains in a Glaciated Low-Relief Landscape" (37), gives some indication of the problems involved in using soil maps to delineate flood plain boundaries. In this study flood plain boundaries determined by engineering methods were superimposed on detailed soil maps along two reaches of the Root River watershed in southeastern Wisconsin. The topography of this area is characterized by gently undulating plains with broad ridges and shallow valleys.

Following are the major results from this study:

1. the 10-year and 100-year floods, as predicted by engineering methods, exceed the limits of alluvial soils in young glaciated landscapes,
2. soil maps do not provide information on flood elevation, stream velocity, or specific flood frequency,
3. it should be noted that flood patterns in urban areas, where structures, fills, and other man-made disturbances have greatly altered the natural hydrology, are especially difficult to predict from soil maps alone. For this reason, soil maps can be used more successfully to delineate flood plains in rural areas.

In contrast to the results of the above study, in the Atlanta Metropolitan Area the flood plain areas indicated by soils are generally larger than those indicated by engineering studies.

In order to administer an equitable and consistent drainage ordinance throughout an area, some design flood should be selected and the appropriate studies done to determine the location of the flood plain elevation. For this reason, and in line with the above discussion, the 100-year flood was chosen to designate the boundaries of the flood plain district.

In order not to have to analyze the 100-year flood plain in every drainage swale and gutter throughout the County, some lower limit of drainage area (five acres) was selected. This was done for administrative convenience and the lower limit could be adjusted depending on local conditions.

4.2 Determination of the 100-Year Flood Contour Elevations -

The recommended procedures to be followed in order to determine the appropriate elevations of the 100-year flood are outlined and discussed in the County's Flood and Erosion Control Manual. In addition this manual lists all approved flood plain reports and maps.

Commentary

Section 4.2 - Determination of the 100-Year Flood Contour Elevations. Ideally the County should prepare a map of the entire area under their jurisdiction with the 100-year flood contour elevation shown on it. In many cases, however, (including all of the areas studied) information is not available to do this. In Ingham County, Fairfax County, and

DeKalb County the computer simulation studies, currently in progress, will give these counties the ability to prepare such a map and keep it up to date. In lieu of this, alternate procedures could be followed:

1. A list of approved reports and maps that establish the 100-Year Flood Contour Elevation for specific areas should be listed in the County's Flood and Erosion Control Manual. (Those reports which are outdated due to urbanization or other changes should be excluded.)
2. When an area being proposed for development is not covered by any available reports, an engineering study should be required in order to establish the water-surface elevation of the 100-year flood.
3. Soils maps which indicate the extent of alluvial deposits can be used as an approximation of the limits of the flood plain but the developer should be free to have an engineering study done to validate the results of these maps. It has been the experience of the Cobb County Engineering Department that these soils maps usually indicate a flood plain much larger than that indicated by appropriate engineering studies. In some areas soil maps have indicated flood plains smaller than those indicated by engineering studies and thus the County may prefer not to allow the use of soil maps for flood plain delineation in these areas.
4. Maps indicating the contours of the historical peak flows can also be used to indicate the flood plain areas but again the developer should be free to have an engineering study done to

determine the evaluation of the 100-year flood.

In all of the areas studied one or more of the above procedures were used.

The details of recommended procedures to be followed in preparing an engineering study should be dealt with in the County's Flood and Erosion Control Manual. This eliminates the need to go into engineering details in the ordinance and allows these procedures to be continually updated. This has proved very effective in Fairfax County where there Erosion Control Manual is kept in a draft form so it can be easily updated. This manual is updated by the Development Department. The Fairfax County personnel indicated that this approach is working quite well and has allowed them the flexibility necessary to keep their erosion control program relevant and up-to-date. Recommended procedures for updating such a manual were discussed in Chapter III.

4.3 *Warning and Disclaimer of Liability - The degree of regulation required by this ordinance is considered to provide a reasonable level of flood protection and is based on engineering and scientific methods of study. Larger floods may occur or flood heights may be increased by man-made or natural causes, such as ice jams and bridge openings constricted by debris. This ordinance does not imply or guarantee that areas outside the flood plain district or land uses permitted within such a district will be free from flooding or flood damages. This ordinance shall not create liability on the part of (Name of*

local unit) or any officer or employee thereof for any flood damages that result from reliance on this ordinance or any administrative decision lawfully made thereunder.

Commentary

Section 4.3 - Warning and Disclaimer of Liability. All of the areas studied have experienced some damages from past flooding. This ranged from extensive damages in Fairfax County and the Chicago Area to minor damages in the Atlanta Metropolitan Area. The main thrust of this ordinance is to lessen or avoid damages from future floods by limiting development within areas subject to flooding and encourage those developments already existing in these areas to take steps to minimize flood damage. A reasonable design flood (100-year flood in this ordinance) is selected as the basis for determining the areas to be covered by certain sections of this ordinance. This does not mean a larger flood will not occur or that some other natural or man-made phenomenon will not occur that will cause damage to existing development. Thus it is not intended nor should it be construed to imply or assure owners, occupants or prospective purchasers of property that no flood of higher elevation will ever occur in the future.

A warning and disclaimer of liability was included as part of the Northeastern Illinois Planning Commission's Suggested Flood Damage Prevention Ordinance but was not included in any of the ordinances studied. This warning and disclaimer of liability should be included for public and judicial information. A determination should be made to be sure this section complies with Local and State laws and procedures.

Section 5.0 - Flood Plain District Uses

- 5.1 Permitted Uses - Within the flood plain district the following uses are permitted with the exception that none of these uses, when acting alone or in combination with other uses, are to be allowed to affect adversely the capacity of the channels or floodways of any tributary to the main stream and/or the main stream, drainage ditch, or any other drainage facility or system, or in any way affect the free flow of flood waters. This must be documented by appropriate engineering plans and studies as discussed in the County's Flood and Erosion Control Manual. The following list of uses is not intended to be all inclusive but only to give typical examples.
- 5.11 Agricultural uses such as general farming, pasture, grazing, outdoor plant nurseries, horticulture, truck farming, forestry, and wildcrop harvesting.
- 5.12 Industrial-commercial uses such as loading areas, parking areas, airport landing strips, and other nonstructural uses.
- 5.13 Private and public recreation uses such as golf courses, tennis courts, driving ranges, archery ranges, picnic grounds, swimming areas, parks, wildlife and nature preserves, target ranges, trap and skeet ranges, hunting and fishing areas,

bicycle, hiking and horseback riding trails.

5.14 *Residential uses such as lawns, gardens, parking areas, play areas, and other non-structural uses.*

Commentary

Section 5.1 - Permitted Uses. All ordinances studied provided some indication of the uses that would be permitted within a flood plain district. Ingham and Fulton Counties were the only areas that listed the permitted uses in a manner similar to Section 5.1 of this ordinance. The uses given in this section consist of a compilation of those uses listed in the different ordinances studied.

Since the uses listed in this section are open-space uses and do not involve structures, fill, or storage of materials, a specific evaluation of these uses should not be necessary. Generally, permitted uses do not obstruct floodways or threaten other land and usually have a low flood-damage potential. A review of the literature concerning flood plain ordinances indicates that some ordinances make all flood plain uses special permit uses (none of the ordinances studied did this). This somewhat cumbersome procedure seems unnecessary for purely open-space uses not involving fill, cut, structures, or storage of materials.

The main purpose for including this section on permitted uses is to give an indication of the County's policy regarding uses of flood plain land. It also serves to inform the public of typical uses allowed in the flood plain district. This list of uses given is not intended to be all inclusive but only to give typical examples.

5.2 Special-Permit Uses - The following uses which involve structures (temporary or permanent), fill, cut, or storage of materials or equipment may be permitted only upon application for a special use permit. Details on such permits are given in Section 6.0 of this ordinance. These uses are also subject to the provisions of Section 5.3 which applies to all flood plain district special-permit uses. The following list of uses is not intended to be all inclusive but only to give typical examples.

5.21 Uses or structures accessory to open space or Special Permit Uses.

5.22 Circuses, carnivals and similar transient amusement enterprises.

5.23 Drive-in theaters, road-side stands, signs and billboards.

5.24 Extraction of sand, gravel and other materials.

5.25 Marinas, boat rentals, docks, piers, wharves.

5.26 Railroads, streets, bridges, utility transmission lines and pipe lines.

5.27 Storage yards for equipment, machinery or materials.

5.28 Supports for structures (excluding fill) where the flood level of the structure is above the 100-Year Flood Contour Elevation but the supports are within the flood plain area.

5.29 Dams and drainage structures constructed to at least the level of the (name of local unit) standards and specifications.

Commentary

Section 5.2 - Special-Permit Uses. Special-permit uses are uses which must receive special attention to prevent obstruction of floodways, threats to other lands from floating debris, and substantial damage to the uses themselves. Therefore, a determination of the appropriateness of the specific proposed use and its location within the flood plain is needed. The important objective of this is to provide a procedure by which these uses can be evaluated on a case-by-case basis. Thus the developer is required to submit detailed engineering studies to document any actions he intends to take. A special permit is given only after a public hearing (by some authorized board) which determines that the conditions set down in the ordinance do exist. In all cases, technical engineering assistance by the County should be used to perform most of the evaluation and advise the review board.

It is also important to coordinate special-permit uses with existing or proposed uses within and outside the flood plain district. This is done to avoid a mixture of incompatible uses (e.g., a drive-in theater adjacent to lands zoned for residential purposes could cause serious conflicts).

Only Ingham and Fulton Counties had provisions in their ordinances similar to special-permit uses included in this ordinance. The other ordinances listed many restrictions to be applied to uses in the flood plain areas but did not provide a means of issuing special permits

for some uses.

This section on special-permit uses should be included in the ordinance for the following reasons:

1. Generally, the uses listed have a low flood-damage potential.

Thus, it seems over-restrictive to exclude them from the flood plain area because of possible damage to these uses.

2. Since the uses listed have the potential to obstruct floodways, an engineering evaluation is needed to evaluate this potential.

3. As in Section 5.1 one of the purposes for including this section on special-permit uses is to give an indication of the County's policy regarding special uses of flood plain land. This policy is inferred by the uses allowed. The main objective of this policy is to keep uses with high damage potential out of the flood plain so not to cause public expense, and keep things out which would harm others. This section also serves to inform the public of typical special uses that might be allowed in the flood plain district.

4. It is a combination of policy decisions (political process) and technical engineering decisions that decide what uses should be allowed in the flood plain district. The special permit allows both of these areas to interact in evaluating any particular proposed use.

5. The procedures outlined in this section also bring under the scrutiny of the public the decision of allowing or disallowing any particular use of flood plain lands.

6. Having to go through the procedure of getting a special-permit reduces the chance of someone developing a property unaware of a potential hazard.

5.3 Standards for Flood Plain Special-Permit Uses - Following are some minimum standards which all special-permit uses must adhere to.

5.31 All Uses - No structure (temporary or permanent), fill deposits (including fill for roads and levees), excavations, obstructions, storage of materials, or equipment, or other use may be allowed as a special-permit use which, acting alone or in combination with existing or future uses, increases flood elevations by 0.1 foot or more beyond the vertical limits set for the flood plain district.

Commentary

Section 5.3 - Standards for Flood Plain Special-Permit Uses.

5.31 All Uses - All of the ordinances studied had some provision similar to this section. The major difference between Section 5.31 of this ordinance and those studied is the exclusion of some of the adjectives used in wording the other ordinances. Words such as significantly, substantially, unduly, or unacceptably were used in several ordinances to describe the limits of the increases of flood heights that were allowed. During the interviews no one was able to give an adequate definition of "significantly, substantially,

unduly, or unacceptably increasing flood heights." It is difficult to administer an ordinance with such vague language.

Since it is possible to determine the capacity of existing channels and the limits of floods associated with different return periods, any increase in flood elevation beyond these limits by 0.1 foot or more is prohibited in this ordinance. The selection of 0.1 foot as a standard in this model urban drainage ordinance was somewhat arbitrary and would not be appropriate for some areas. The allowable increase in flood elevation that is selected for a specific area should be related to local conditions and based on good engineering judgment. This approach should be much easier to administer and also provide a more definite description of the restrictions to which developers will be subjected. Selecting some small allowable increase in flood heights (0.1 foot in this ordinance) avoids having to look at very small rises. This can save administrators a great deal of time and cost.

This approach also allows a community the option of allowing for future development when establishing the limits of the flood plain drainage district by basing these limits on projected future land use conditions rather than existing land use. Depending on local statutes and conditions the following options might be used to obtain downstream flood plain areas necessitated by upstream development:

1. purchase of needed flood plain areas,
2. purchase flood plain easements through affected areas,
3. provide cash compensations to the owners of affected areas.

In addition, the evaluation of the effect of a proposed use in causing increases of flood heights is based not just on the effect of the single use acting alone (which was done in several of the areas studied), but upon the reasonable assumption that other landowners within the hydraulic reach must be treated equitably and allowed to develop to an equivalent extent. Therefore, the cumulative effects of such encroachments must be considered. In the Chicago and DeKalb areas some developments (five acres or less in the DeKalb area) were excluded from some of the regulations but DeKalb County felt this led to many small developments. In other words, developers would divide large developments into several small ones to avoid the regulations. This again points up the necessity of looking at the cumulative effects.

5.32 *Filling, Dumping, Excavating, and changes in Topography -*

The following restrictions shall pertain to all filling, dumping, excavating, and changes of topography within the flood plain district.

- (1) *No filling or dumping shall be allowed which will increase flood heights beyond the limitations set in Section 5.31 of the ordinance or adversely affect the hydraulic efficiency or capacity of the*

flood plain drainage district unless such filling is compensated for by excavation in or contiguous to the filled area, and does not adversely affect the hydraulic characteristics of the flood plain. The term filling as used here shall mean structures, whether temporary or permanent; obstructions; storage of material; or any other placement of matter in such a manner that may decrease flood plain volume.

- (2) No changes in topography (filling or excavation) will be allowed if these changes will result in a concentration of the natural flow of water such as to cause or increase drainage problems. The grading of any area shall be done in a manner to maintain proper drainage throughout.
- (3) Any fill proposed to be deposited in the flood plain must be shown to have some beneficial development purpose and the amount thereof not greater than is necessary to achieve that purpose, as demonstrated by a plan submitted by the owner showing the uses to which the filled land will be put and the final dimensions of the proposed fill or other materials.
- (4) Such fill or other materials shall be protected against erosion as discussed in the County's Flood and Erosion Control Manual.

Commentary

Section 5.32 Filling, Dumping, Excavating, and Changes in Topography. The main purpose of this section is to minimize filling in the flood plain areas, to preserve flow capacity, and to assure that fill placed in these areas will have a beneficial purpose and be protected against erosion. Following is a discussion of the restrictions included in this section.

- 5.32 (1) The adverse hydraulic effects of filling and dumping in a flood plain can be neutralized if compensatory storage is provided, designed so that the hydraulic conductivity of the total drainageway, including the flood plain, is not reduce. Compensatory storage seeks to provide artificial flood storage capacity in areas where natural storage capacity has been lost or reduced as a result of development. The principle of compensatory storage is simple: for each unit volume (yd^3) of natural storage that is eliminated, an equal unit volume of capacity should be substituted. Thus, storage capacity will remain constant within a given area despite the fact that filling and/or erection of structures may occur. Of primary importance is not the exact balancing of volumes of cuts and fills but preserving the hydraulic characteristics of the flood plain areas. Cutting and filling in flood plain areas disturbs and can destroy an areas ecology. Thus it might be argued from an ecological perspective that balancing cut and

fill is probably worse than fill alone without compensation. As written, this proposed ordinance does not address itself to many ecological considerations. To do such would add great complexity to the ordinance and possibly overshadow (or at least confuse) the main purposes of the ordinance. In addition, at this time many of the ecological consequences associated with different actions (e.g., clearing land, channelization, etc.) are not fully understood. Thus, it is often difficult to get agreement concerning the cause of damages and remedial actions that should be taken. If a community wants to protect the ecology of certain areas, it should adopt additional ordinances and regulations designed for this purpose.

During several interviews, the author made the suggestion that no filling within the flood plain be allowed. The general reaction to this was that although this might be a good idea from an engineering or environmental perspective, it is often not from an economic viewpoint. It was pointed out that in many areas there is a considerable amount of flood plain area where land values are high. Thus political and developmental pressures are used to allow some filling in these areas. Accepting this, some provisions should be included in the ordinance to protect the hydraulic conductivity of the drainageway.

All of the ordinances studied had some provisions for controlling filling of the flood plain but only the cities of Atlanta and Chicago, and DeKalb, Fulton, and Fairfax Counties included provisions for compensatory storage.

5.32 (2) Not just filling but any change in topography can adversely affect adequate drainage. It has been the experience of the Cobb County Engineering Department that developing areas in a manner such that natural flows are concentrated at one or more points can cause drainage problems for downstream areas. Although the total amount of flood water discharged from a site may not have changed, in many developments the water is diverted from natural flood plain areas and is concentrated at points where the flood plain does not have adequate storage capacity. Only the City of Atlanta's grading ordinance had a provision similar to this section of the proposed ordinance.

5.32 (3) It is not the intent of this section of the ordinance to encourage indiscriminate filling of the flood plain areas. Any proposed fill should have some beneficial purpose and the filled areas should not be larger than required for this purpose. Only Ingham County's ordinance had a section specifically stating that proposed filling must have a beneficial purpose and must be limited.

5.32 (4) Filled areas are more susceptible to erosion problems than other areas. Although erosion and sediment control regulations are dealt with in another section of this ordinance, this section is included as an additional reminder of the problems involved with filled areas. This provision is similar to the Ingham County ordinance.

The City of Atlanta also has a provision to control erosion and sediment from filled areas.

5.33 Structures (temporary or permanent) - The following restrictions shall pertain to all structures (temporary or permanent) located within the flood plain district.

- (1) Structures shall not be designed for human habitation unless flood-proofed (as per specifications given in the County's Flood and Erosion Control Manual).
- (2) Structures shall have a low flood-damage potential.
- (3) The structure or structures, if permitted, shall be constructed and placed on the building site so as to offer the minimum obstruction to the flow of flood waters.
- (4) Structures and all other stored materials shall be anchored or restrained to prevent them from floating away, which may result in damage to other structures, restriction of bridge openings and other narrow sections of the stream or river.
- (5) All buildings located within the flood plain

district shall be flood-proofed up to an elevation of at least that of the 100-Year Flood Contour Elevation within ___ months after this ordinance is adopted. If the owner chooses not to flood-proof to that level he must file a written statement assuming any flood damages to his structure and contents.

- (6) Service facilities such as electrical and heating equipment shall be constructed at or above the 100-Year Flood Contour Elevation or flood-proofed.

Commentary

Section 5.33 Structures (temporary or permanent). Although all ordinances studied had some provisions for controlling structures within flood plain areas, each ordinance had a different approach and none contained all the provisions listed in this ordinance. Following is a brief discussion of the six restrictions described in this section.

- 5.33 (1) Structures designed for human habitation are prohibited, unless flood-proofed, because of either high water velocities or flood damage ordinarily associated with the flood plain district. All of the ordinances studied prohibited the use of structures within the flood plain district for human habitation. Several of the ordinances specifically stated that if the structures were built on stilts or columns and the first flood elevation was a certain distance (varied with the different

ordinances from 0 feet to 3½ feet) above the designated flood plain contour elevation, then the structures could be used for human habitation. This was part of the Chicago, Tampa, Fulton County, and Fairfax County ordinances. Since this situation was covered within the list of uses given in Section 5.28 it was not made a part of this section.

- 5.33 (2) This section reaffirms an earlier statement that uses permitted as special-permit uses must have a low flood-damage potential. Ingham County's ordinance included such a provision.
- 5.33 (3) Although this section could be considered part of engineering design specifications and would thus be included in the County's Flood and Erosion Control Manual, it is included as part of this ordinance because of its possible impact on land use and zoning decisions. It might be possible to utilize an area within the flood plain district for some uses (long narrow buildings all placed parallel to the direction of flood flow) but not others. This section is consistent with Ingham County's ordinance.
- 5.33 (4) This section is included to help prevent damage to proposed structures and other structures or facilities downstream. Ingham County's ordinance included a similar section.
- 5.33 (5) Both Chicago's and Tampa's ordinances contained some

reference to flood-proofing structures. Tampa's ordinance also contained a considerable amount of detail concerning what flood-proofing measures could be required. The details or engineering specifications and design associated with certain flood-proofing measures can be more adequately dealt with in the County's Flood and Erosion Control Manual and not in the ordinance. The question of flood-proofing is heavily dependent upon the economics of the given situation. The County has the obligation to inform the owner of a building within the flood plain that his property is subject to storm damage. It is then up to the owner to determine whether it is more economical to flood-proof the structures or suffer flood damages. As long as no other property will be damaged by not flood-proofing a structure, the decision concerning the use of flood-proofing should be up to the individual owners. If the owners choose not to flood-proof to the 100-Year Flood Contour Elevation, a written statement is required to confirm that both the County and owners are aware of the situation and of the choice that the owners have selected.

- 5.33 (6) Since electrical and heating equipment is especially vulnerable to water damage special attention should be given to these facilities. This section is consistent with Ingham County's ordinance.

5.34 *Storage of Material and Equipment - The following*

restrictions shall pertain to the storage of material and equipment within the flood plain district.

- (1) The storage or processing of materials that are in time of flooding buoyant, flammable, explosive, soluble, expansive, or could be injurious to human, animal or plant life is prohibited.
- (2) Storage of other material or equipment may be allowed if not subject to major damage by floods, unless owner files a written statement assuming any flood damages to his property, and if firmly anchored, restrained, or enclosed to prevent them from floating away.

Commentary

Section 5.34 Storage of Material and Equipment. Storage of material that is buoyant, soluble, flammable or otherwise injurious when carried by flood waters is prohibited for health and safety reasons. Other materials and equipment can be stored if they will not cause much damage and if they are anchored or enclosed to prevent flotation. Only Chicago and Ingham County had provisions in their ordinances that specifically dealt with the storage of material and equipment within flood plain areas. Their provisions were similar to the ones included in this ordinance.

The provisions concerning damage to stored material or equipment

can be waived if the owners submit to the County a written statement assuming all flood damages. This written statement is required to confirm that both the County and owners are aware of the owners decision to assume all flood damages to his property.

5.35 *Public Utilities and Facilities - The location, design, elevation and construction of all public utilities and facilities such as sewer, gas, electrical, water systems, streets, bridges, and culverts shall be in such a manner as to minimize or eliminate damage by flooding, flow obstruction, and sewer overflows.*

Commentary

Section 5.35 Public Utilities and Facilities. Only Chicago, Atlanta and Ingham County's ordinances had provisions that specifically dealt with the location of public utilities within flood plain areas. In both Chicago and Ingham County, a permit from the State is required before any utilities can be located within flood plain areas. In Ingham County, a permit from the Drain Commissioner is also required and all utilities must be located at least four feet below the invert of the stream.

Although little data were available in the areas studied to determine to what extent utilities posed problems in flood plain areas, personnel with the City of Atlanta and DeKalb County expressed the opinion that there were problems with some existing installations. Quoting from a report written by the DeKalb County Drainage Engineer, "one of the principal impediments to natural flow is found in culverts and

bridges with insufficient openings and sanitary sewer lines across stream channels." In addition, the personnel in Chicago reported major pollution problems resulting from sewer overflows during storm events. From the results of the interviews it seems clear that some control of public utilities and facilities located within flood plain districts is needed.

Section 6.0 - Special Use Permits

6.1 Application for Special Use Permit - Any use listed in this ordinance as requiring a special use permit may be allowed only upon application and issuance of a special use permit by the local designated agency or board - hereafter referred to as the Board).

Commentary

Section 6.0 - Special Use Permits. This section sets out the procedure for passing upon special use permits for flood plain areas. Emphasis is upon the special aspects of this evaluation which supplement usual procedures for evaluating special exceptions, conditional uses, and so forth.

It was pointed out in the commentary on Section 5.2 - Special Permit Uses, that only Ingham and Fulton Counties had provisions in their ordinances similar to Section 5.2 of this ordinance. In neither of these ordinances, or in any of the other ordinances studied, was there a section dealing with the details concerning special use permits. The Tampa ordinance did include a section concerning appeals to the Board of Adjustment but this section had neither the scope nor detail included in this ordinance.

In some of the literature it was suggested that a section specifically dealing with special use permits and/or variances should be included in a flood plain ordinance. Section 6.0 of this ordinance is modeled after a similar section in an ordinance described in, "Regulation for Flood Plains," American Society of Planning Officials, (25).

This section of the ordinance is important for the following reasons. Zoning, of which flood plain regulations are a part, has had many critics through the years. Many of these critics point to the large number of variances and special use permits granted as a sign of weakness in the zoning process. There are times when special use permits are justified, but large numbers of these permits will tend to dilute the main objectives of the ordinance. For this reason it is desirable to limit special use permits by setting up some definite procedures to be followed in passing on such permits. It is also necessary to specify definite factors which should be considered when a special use permit is evaluated and some typical conditions which can be attached to any such permit.

By adopting a detailed section on special use permits, the Board has some definite guidelines that add continuity to the decision process. Also, the public is informed as to what factors will be evaluated and the procedures to follow regarding these permits. Since the Board and the Public will need this information pertaining to special use permits, it should be included in the ordinance rather than in the County's Flood and Erosion Control Manual which is concerned more with Engineering Data and Specifications.

Considering all these aspects, a detailed section on special use

permits will go a long way in fulfilling the objectives of making the ordinance an effective policy statement.

Since none of the ordinances studied had a section similar to section 6.0 of this ordinance, it will not be possible to make any comparisons pertaining to these regulations.

Section 6.1 - Application for Special Use Permit. If the use is one listed (or implied) in the ordinance as requiring a special use permit then an application to the Board is required.

6.2 Procedure to be Followed by the Board in Passing on Special Use Permits - Upon receiving an application for a special use permit the board shall, prior to rendering a decision thereon:

- (1) Require the applicant to furnish as much of the following information as is necessary for determining the suitability of the particular site for the proposed use:
 - (a) Plans showing the nature, location, dimensions, and elevation of the lot, existing or proposed structures, fill, excavation, storage of materials, flood-proofing measures and the relationship of the above to the location of the channel and flood plain district.
 - (b) A typical valley cross-section showing the channel of the stream, elevation of land areas adjoining each side of the

channel, cross-sectional areas to be occupied by the proposed development and 100-Year Flood Contour Elevation.

- (c) Plans showing elevations or contours of the ground; flood plain district, pertinent structures, fill or storage elevations; size, locations and spatial arrangement of all proposed and existing structures on the site; location and elevations of streets, water supply, sanitary facilities; photographs showing existing land uses and vegetation upstream and downstream, soil types and other pertinent information.
 - (d) A profile showing the slope of the bottom of the channel or flow line of the stream.
 - (e) Specifications for building construction and materials, flood-proofing, filling, dredging, grading, channel improvement, storage of materials, water supply, and sanitary facilities.
- (2) Transmit a copy of the above information to the County Engineering Department for their review and comment.
 - (3) Based upon the technical evaluation of the

Engineering Department, the Board shall determine the specific flood hazard at the site and shall evaluate the suitability of the proposed use in relation to the flood hazard.

Commentary

Section 6.2 - Procedure to be Followed by the Board in Passing Special Use Permits.

- 6.2 (1) This section indicates the type of information the Board can require the applicant to supply. This information is of two general types: (1) description of the physical characteristics of the site, including a typical valley cross-section, a profile of the stream and vegetative cover, and other potential obstructions to flow. (2) A description of the proposed development which will permit an evaluation of its suitability based upon the flood hazard present at the particular site, including the nature of the use, its spatial arrangement, structural specifications, and other pertinent facts.
- 6.2 (2) This section requires the Board to transmit the information from Section 6.2 (1) to the County Engineering Department. This department uses the information to check the flood hazard at the site and to evaluate the suitability of the proposed use in relation to the flood hazard. The County Engineering Department may suggest modifications of the proposed development necessary to

meet the requirements of this ordinance.

- 6.2 (3) Based upon the evaluation by the County Engineering Department, the Board determines the suitability of the proposed use in relation to the flood hazard. The factors which the Board is to consider in evaluating the proposed special-permit use are found in Section 6.3.

The Board may attach additional conditions as authorized by Section 6.5.

- 6.3 Factors Upon Which the Decision of the Board Shall be Based - In passing upon applications for special use permits, the Board shall consider all relevant factors specified in other sections of this ordinance and:

- (1) An evaluation to show that the proposed use will not reduce the capacity of the floodway or increase flood heights beyond those allowed in this ordinance.
- (2) The danger that materials may be swept onto other lands or downstream.
- (3) The proposed water supply and sanitation systems and the ability of these systems to prevent disease, contamination, and unsanitary conditions.
- (4) The importance to the community of the services provided by the proposed facility.
- (5) The requirements of the facility for a waterfront location.

- (6) The availability of alternative locations not subject to flooding.
- (7) The compatibility of the proposed use with existing development and development anticipated in the near future.
- (8) The relationship of the use to the comprehensive plan and flood plain management program for the area (if available).
- (9) The safety in times of flood of access of ordinary and emergency vehicles to the property.
- (10) The expected heights, velocity, duration, rate of rise, and sediment transport of the flood waters expected at the site (if the Board feels this information is needed).
- (11) Such other factors as are relevant to the purpose of this ordinance.

Commentary

Section 6.3 - Factors Upon which the Decision of the Board shall be Based. This section lists the general factors which the Board shall consider in evaluating the application for a special-use permit. These are in addition to the specific requirements contained in Section 5.0 for flood plain uses. Since factor ten (10) would necessitate a considerable amount of engineering work for a general requirement, it should be left up to the Board whether or not such information is needed to evaluate a specific application for a special-use permit.

6.4 Time for Acting on Application - The Board shall Act

on an application in the manner described within ___ days from receiving the application, except when additional information is required by the Board. The Board shall render a written decision within ___ days from the receipt of such information.

Commentary

Section 6.4 - Time for Acting on Application. This section sets a time limit within which the Board must act on an application for a special use permit. The time limit can be extended if the applicant is required to supply additional information for a proper evaluation of the proposal. The basic purpose of this section is to set some reasonable time limit within which the Board must render a decision.

6.5 Conditions Attached to Special Use Permits - Upon consideration of the factors listed above and the purposes of this ordinance, the Board may attach such conditions to the granting of special use permits or variances as it deems necessary to further the purposes of this ordinance. Following are some examples of such restrictions:

- (1) Modification of waste disposal and water-supply facilities.
- (2) Limitations on periods of use and operation.
- (3) Imposition of operational controls, sureties and deed restrictions.

- (4) Requirements for construction of channel modifications, dikes, levees and other protective measures.
- (5) Flood-proofing measures consistent with the standards and specifications for flood-proofing contained in the County's Flood and Erosion Control Manual.

Commentary

Section 6.5 - Conditions Attached to Special Permits. This section specifically authorizes the Board to attach conditions to the issuance of variances or special use permits and lists some of these conditions. By including flood-proofing measures as part of this ordinance, certain responsibilities are placed on the County. The review of flood-proofing measures by the County will necessitate the hiring of qualified personnel knowledgeable in this area. As in many sections of this ordinance, the County will have to decide whether it is justified in terms of available funds and budget priorities to employ the personnel needed to justify the inclusion of this section in the ordinance.

Section 7.0 - Nonconforming Uses

7.1 A structure or the use of a structure or premises which was lawful before the passage or amendment of this ordinance but which is not in conformity with the provisions of this ordinance may be continued subject to the following conditions:

7.11 No such use shall be expanded, changed,

enlarged, or altered in a way which increases its degree of nonconformity.

- 7.12 No structural alteration, addition or repair to any nonconforming structure shall exceed ___ percent of its value at the time of its becoming a nonconforming use, unless the structure is permanently changed to a conforming use.
- 7.13 If such use is discontinued for ___ consecutive months, any future use of the building premises shall conform to this ordinance.
- 7.14 If any nonconforming use or structure is destroyed by any means, including floods, to an extent of 50 percent or more of its value, it shall not be reconstructed except in conformity with the provisions of this ordinance.
- 7.15 Uses which become nuisances under conditions of prevailing ordinances shall not be entitled to continue as nonconforming uses.
- 7.16 Except as provided in Section 7.15, any use which has been permitted as a special-permit use shall be considered a conforming use.
- 7.17 Any alteration, addition, or repair to any nonconforming structure which would result in substantially increasing its flood-damage potential is prohibited.
- 7.18 The County shall prepare a list of those

nonconforming uses which have been flood-proofed or otherwise adequately protected in conformity with Section 6.5 (1) - (5). This list shall be presented to the Board which may issue a certificate to the owner stating that as a result of these corrective measures such uses are in conformity with the provisions of this ordinance.

- 7.19 If the restrictions placed on a particular use change (e.g., lowering of 100-Year Flood Contour Elevation), a certificate will be issued to the owner stating that a result of these measures such use is in conformity with the provisions of this ordinance.

Commentary

Section 7.0 - Nonconforming Uses. The subject of nonconforming uses is a troublesome and complex area of zoning law. An administrative procedure for handling nonconforming uses would be desirable. The process should permit a case-by-case determination of the probable effect of the change, continuance, or termination of the uses and take into account social harm from continued existence and private injury caused by termination. In some cases, special enabling legislation is likely to be needed for such an administrative procedure.

Section 7.11 - 7.13 - Expansion, Alteration and Termination. These sections limit the expansion and alteration of nonconforming uses and provide for their termination when not occupied.

Section 7.14 - Reconstruction. This section requires

reconstruction of a destroyed structure to be in conformance with this ordinance. The literature concerning drainage ordinances indicates that many ordinances restrict the right of the nonconforming use to restore a structure damaged by fire, flood, or other calamity. Commonly they prohibit restoration in excess of 50 percent of assessed value, fair market value, or replacement values (in descending order of stringency). Enforcing such a provision against a flood victim could prove unpopular since it seems to be like kicking a man when he is down. Therefore, the provision is added that the Board may permit reconstruction of a use if it is adequately protected against flood damage.

Section 7.15 - Nuisances. This section makes clear that nuisances are not to be given protection as nonconforming uses. An example of a nuisance is a floodway use which obstructs flows, causing substantial injury to other lands or to the public.

Section 7.16 - Special-Permit Use. Since a drainage ordinance must by its nature make use of the special use permit technique, it is well to point out that special-permit uses are conforming uses.

Section 7.17 - Alteration, Addition and Repair. Any substantial modification of a nonconforming use should, if possible, reduce its vulnerability to flood damage and certainly not increase it. The reasonable administration of this and other flood-proofing requirements for nonconforming uses will depend upon an evaluation of the flood-hazard, safety considerations, value of the use, and the cost of the particular flood-proofing technique required.

Section 7.18 and 7.19 - Changing to Conforming Uses. The stigma attached to a designation as a nonconforming use because of failure to

comply with flood-hazard restrictions can be a financial burden to the owner who is trying to sell or obtain financing. In some instances, the degree of nonconformity may be relatively minor. The possibility of obtaining such a certificate could also encourage flood-proofing.

Although a general section concerning nonconforming uses is usually contained in the County's zoning regulations, drainage and flood control regulations have some unique restrictions which primarily affect only those areas within or adjacent to the flood plain areas. In addition, many times a flood plain or drainage ordinance, although a part of the zoning regulations, is written as a separate document and becomes physically detached from the overall zoning regulations. For these reasons, a separate nonconforming use section should be included within the drainage ordinance. None of the drainage ordinances studied included such a section although much of the literature concerning drainage ordinances recommends that some mention of nonconforming uses be included.

Section 7.0 of this ordinance is modeled after a similar section in an ordinance described in "Regulations for Flood Plains," American Society of Planning Officials, (25).

Section 8.0 - Hydrologic and Hydraulic Studies

A hydrologic and hydraulic study of the proposed development shall be submitted with each application for a development permit. These studies will be used to establish the location of the 100-Year Flood Contour Elevation (if this information is not already available) and also to design retention and detention storage facilities to limit the storm runoff from the development to that which can be contained within the flood plain district. Thus, these studies will be used to

evaluate the total effects a development under review may have upon existing and proposed developments and drainage facilities within the development area. As part of these studies, the effects of the 100-Year Flood on proposed and existing drainage facilities should be determined.

In addition, the effects the proposed development will have on existing developments, drainage facilities, and property upstream and downstream from the proposed development must be evaluated. These studies must show that the proposed development will not create or worsen drainage problems upstream or downstream from the proposed development, and that the limits of the flood plain district will not be exceeded.

If the limits of the flood plain district would be exceeded by the increased runoff from a proposed development for the 100-Year Flood or if increased runoff from any design flood, up to and including the 100-Year Flood, would create or worsen drainage problems, then an engineering design must be included in the hydrologic and hydraulic study. This design must show how the increased runoff from the proposed site will be controlled or what changes in the drainage system downstream will be made to accommodate this increased runoff so that the limits of the flood plain district will not be exceeded and drainage problems will not be created or worsened.

Commentary

Section 8.0 - Hydrologic and Hydraulic Studies. All of the ordinances studied had different requirements pertaining to hydrologic and hydraulic studies. Following are some selected highlights from the requirements of the different areas. Because of the many

differences between the requirements pertaining to hydrologic and hydraulic studies in the different areas studied and the importance of these studies as they relate to the different sections of this ordinance, the following commentary will be much more detailed than the other commentaries in this chapter. This will enable the reader to quickly compare the requirements of the different areas studied. Although most of the ordinances studied did not specify the use of any particular hydrologic procedures, the personnel interviewed indicated that certain hydrologic procedures are recommended. The hydrologic procedures recommended by each of the areas is indicated in the following commentary. These procedures are being used to determine peak runoff rates and volumes for design of drainage facilities. Since the County's Flood and Erosion Control Manual would contain information related to hydrologic procedures, no reference to any particular hydrologic method of analysis is included in the proposed model urban drainage ordinance.

DeKalb County

1. A Hydrologic and hydraulic study and analysis of storm water runoff is required for all developments.
2. The 100-Year Flood Contour Elevation must be determined for any development adjacent to or encompassing a flood plain drainage district or adjacent to or encompassing a stream which generates a flow in excess of 500 cubic feet per second under a 100-year design storm.
3. Storage facility studies are required for all developments that generate an increase in runoff in excess of one cubic foot per second under a 10-year design storm. These studies

are done to determine whether or not storage facilities (with outlet control) are needed to control storm runoff.

Studies are based on a 10-year design storm with no increase in runoff allowed for this storm

4. The rational method is recommended for all studies.

City of Atlanta

1. Hydrologic and hydraulic studies are only required when the City personnel feel there is a need.
2. Storage facility studies are required on some developments. The City personnel determine which developments (on a case-by-case basis) will need these studies. Studies are based on a 100-year design storm with no increase in runoff allowed for all design storms up to and including the 100-year storm.
3. The rational method is recommended for hydrologic studies dealing with areas up to 50 acres. The Burkli-Ziegler formula is recommended for studies dealing with larger areas.

Fulton County

1. Hydrologic and hydraulic studies may be required if the County personnel feel there is a need. This need is usually based on:
 - A. whether the developer wants to fill or grade within the flood plain,
 - B. whether the development is of such size that it will increase the 100-Year Flood Contour Elevation by one foot or more,
 - C. whether it appears that the development will increase

the runoff so as to create a "hazard".

If the development causes any of these conditions, then a study is usually required.

2. If the proposed development increases runoff so as to create a "hazard" then storage facility studies are required. These studies are based on a 10-year design storm with no increase in runoff allowed for this storm.
3. The Burkli-Ziegler formula is recommended for all hydrologic studies.

Clayton County

1. Hydrologic and hydraulic studies are only required when the county personnel feel there is a need.
2. Talbot's formula and the rational method are recommended for hydrologic studies.

Ingham County

1. Hydrologic and hydraulic studies are required for all developments. The 10-year one hour storm is used as the design storm for all drainage facilities.
2. The rational method is recommended for hydrologic studies.
3. In the near future the County will be using computer simulation for the design and evaluation of all drainage facilities.

Chicago

1. Hydrologic and hydraulic studies are only required when the Chicago Metropolitan Sanitary District feels that a proposed development might cause drainage problems.
2. Storage facility studies are required for all non-residential

developments exceeding 5 acres, and for all residential developments exceeding 10 acres which have or will have impervious area of 60 percent or greater. In designing storage facilities, the volume of storage required is based on a 100-year storm for any and all durations while the storage outlet design is based on a 3-year storm.

3. The rational method is recommended for hydrologic studies.

Fairfax County

1. The County requires hydrologic and hydraulic studies for all developments, showing the flooding that will result when the 100-year design storm passes through the proposed drainage system.
2. Storage facility studies are done on a case-by-case basis when the County personnel feel there is a need. The volume of storage required is based on a 100-year design storm. The design of the storage outlet varies depending on the capacity of the drainage facilities downstream from the proposed development.
3. The rational method is recommended for hydrologic studies dealing with areas up to 200 acres. Anderson's formula is recommended for calculating runoff from larger areas. The Soil Conservation Service's Hydrograph Method has been used for the design of several detention storage facilities. In the near future the County will be using computer simulation for the design and evaluation of drainage facilities.

City of Tampa

1. Hydrologic and hydraulic studies are required for all developments.
2. Storage facility studies are done on a case-by-case basis.

The Public Works Department determines whether or not a development will need such a study. Two types of storage facilities have been used in the City of Tampa:

- A. Basins with no outflow - volume of storage is based on a 50-year storm of 24-hours duration; most of the water leaves these basins by infiltration with small amounts being evaporated.
- B. Basins with outlets - volume of storage required is based on a 25-year storm, under developed conditions, for all durations up to and including 24 hours. The storage discharge design is based on a 25-year storm using predeveloped conditions.

3. The rational method is recommended for all hydrologic studies.

Following is a brief discussion of some of the requirements expressed in Section 8.0 of this ordinance.

Four of the eight areas (the City of Tampa, DeKalb, Ingham, and Fairfax Counties) require hydrologic and hydraulic studies for all developments while the other areas only require them when the County or City personnel feel there is a need. In Cobb County, it has been found that hydrologic and hydraulic studies are necessary in order to determine whether or not a specific site will have drainage problems. For small developments these studies are usually uncomplicated and do not

demand much time or expense. From only a site survey and visual inspection it may be possible for an experienced drainage engineer to determine whether or not some sites will experience drainage problems or cause drainage problems for other areas. However, many of the areas studied had personnel reviewing the drainage plans who were recent engineering graduates, long-term employees with little or no engineering education, or highly trained and educated persons in areas other than drainage (one county had an aeronautical engineer checking their drainage plans). Thus, in order to adequately assess the entire drainage situation for each development, a hydrologic and hydraulic study should be required.

For the County, the question that comes out of this issue is whether or not the benefits justify the cost. In other words, is the problem great enough to justify an increase in the County budget to deal with it? Whether or not the County requires hydrologic and hydraulic studies for each development will depend on local conditions and problems but at least the County should consider the costs and benefits of requiring or not requiring such studies.

In analyzing the drainage for a proposed development, the following should be considered and are included in the proposed ordinance.

1. A detailed evaluation should be made of the proposed on-site drainage facilities so that these facilities will not create drainage problems within the proposed development.
2. An evaluation of the effects that the design flood will have on drainage facilities and land area upstream and downstream from a proposed development should be made. This is

necessary so that adjacent property owners and others within the drainage area will not be damaged from the increased runoff caused by the proposed development.

3. If the existing drainage system can safely accommodate, or be improved to accommodate, the increased runoff from the development without causing damage to other property owners or exceed the limits of the flood plain district, then control over the increased runoff is not needed. In other words, the existing capacity of the drainage system should be used before storage facilities are required. This is consistent with the idea, expressed in an earlier section of this ordinance, that a county or city can set the limits of the flood plain district to allow for the increased runoff from developing areas.
4. If the limits of the flood plain district would be exceeded by increased runoff from a proposed development, for the 100-year flood, some means must be provided to limit the 100-year flood runoff peak from the development so the limits of the flood plain district will not be exceeded. This is usually done by using storage facilities with controlled outlets.
5. If increased runoff from any design flood up to and including the 100-year flood would create or worsen drainage problems, some facilities must be provided to correct this situation. This will protect adjacent property owners against increases in runoff. This does not mean that the engineer must check his design for all possible design floods (of

which there are an infinite number). Usually it is sufficient to determine the results of say the 5, 25, and 100-year floods, although the number of design floods used in evaluating a particular design will depend on one or more of the following:

- A. physical characteristics of the drainage area and drainage system downstream from the area being developed,
- B. economic considerations of possible damages from increased runoff,
- C. political, and aesthetic considerations.

DeKalb County requires a study and storage facilities for all developments that increase runoff by more than one cubic foot per second. All of the other areas studied require storage facility studies only on a case-by-case basis, when the County or City personnel feel it is necessary. Not all developments need storage facilities and some guidelines should be established, and expressed in the ordinance, to determine when these facilities should be required. Section 8.0 of this ordinance sets some definite guidelines for this purpose.

Hydrologic computer simulation would be an invaluable aid in evaluating the effects of a proposed development and aiding the County and private engineering consultants in preparing and evaluating the necessary engineering studies. Simulation would be especially helpful in designing and evaluating the effects of storage facilities and the interrelationships between several storage facilities.

Before adopting this or any ordinance, a local community would want to thoroughly evaluate the economic implications of the above

actions. Economic studies should be done during the preliminary phases of formulating the drainage program so that they can be used to help design a better program rather than evaluating the consequences of actions already taken. These studies should consider the economic consequences to the County, to development interests, and to the private citizens. This subject of economic studies was not dealt with in depth as part of this study, and none of the areas studied had published results of any such studies.

Section 9.0 - Improvements Required

If the required hydrologic and hydraulic studies reveal that the proposed development would cause increased flood stages so as to increase the flood damages to existing developments or property, or increase flood elevations beyond the vertical limits set for the flood plain district, then the development permit shall be denied unless one or more of the following requirements are met:

- 9.1 On-Site Storage - Provide on-site storage for the increased volume of storm water that results from the proposed development, and provide release mechanism to limit the storm runoff from the storage facility to that which would have been expected from the development site under natural or pre-developed conditions for all design floods which have an adverse effect on existing drainage, up to and including the 100-year flood. Limit the 100-year flood runoff peak from the development so that*

the vertical limits of the flood plain district are not exceeded.

- 9.2 Off-Site Storage - Provide or contribute proportional funding for off-site storage facilities that will control storm runoff so that the limits of the flood plain district are not exceeded and upstream and downstream property is not damaged by increased storm runoff. In using off-site storage, an engineering study must be done to show that property located between the proposed development and the storage facilities will not be damaged by increased runoff.

Commentary

Section 9.1 and 9.2 - Storage Facilities. Of all the ordinances and literature that were studied during the course of investigation for this thesis, the following paragraphs embody many of the essential elements that should be considered before enacting regulations that require storage facilities.

From a Statement by the Chicago's Blue Ribbon Sub-Committee on Flood Control

It is not the intent of the Sub-Committee that numerous small puddles and ponds be constructed throughout the metropolitan area. Such scattered ponds may create a nuisance and possible health hazards and fail to provide flood protection if not adequately maintained. Rather, the purpose is to encourage the development of well maintained landscaped lakes to act jointly as detention reservoirs and recreation facilities or aesthetic focal points in new village parks, either in incorporated or unincorporated developments, shopping centers, and industrial parks. Also, considerable storage of storm water can be provided at its source without undue nuisance if properly engineered; for example, detention on flat roofs, parking lots, gutters, yards, underground storage, etc.

From Fairfax County's Policy on
Retention of Storm Waters

It is the intent of this policy to encourage the use of various methods for the on-site retention of storm waters in the interest of minimizing the adverse effects of increased storm water runoff, (resulting from development of land within the County), on downstream drainage ways such as stream valley parks and natural flood plains.

Temporary on-site retention of storm water is desirable in many cases to alleviate existing downstream drainage problems when the drainage system is clearly inadequate and its expansion is either financially prohibitive or aesthetically unacceptable.

The release rate from any temporary ponding area should approximate that of the area prior to the proposed developments for the design storm, but adequate alternate drainage must be provided to accommodate major storm flows.

Retention pools or basins in parks, playing fields, parking lots or storage areas can be constructed to reduce peak runoffs downstream by providing temporary on-site storage. Care must be taken to see that such temporary ponds do not become nuisances or health hazards.

From Design Criteria City of Tampa

When it is found to be economically advisable to construct retention basins for a drainage system, the design should make such facilities an asset instead of a liability to the community by:

- a) making them useful for recreation, parks and other public purposes,
- b) eliminate hazardous and unhealthy conditions normally associated with such facilities,
- c) permit maintenance with standard equipment and at minimal expense,
- d) be suitable for installation of landscaping and recreation facilities and public use.

From Manual of Procedures for the Administration of the Sewer
Permit Ordinance - Chicago Metropolitan Sanitary District

It is recognized that in order to better serve the long-range interests of the local communities and the metropolitan area, comprehensive basin-wide planning for flood control should be

formulated, adopted and implemented. Comprehensive planning is far more beneficial than the proliferation of small, on-site detention areas, although on-site detention areas do provide protection and are acceptable for the compliance with this ordinance.

On-site retention and detention facilities have become very popular among County and City governments in the Atlanta Metropolitan Area. DeKalb County requires some storage facility on almost every development in the County. Many of the other metropolitan counties are following DeKalb's lead and are also requiring storage facilities for new developments. There are three major considerations that should be evaluated before storage facilities are required for all developments.

1. Will the proliferation of small on-site storage areas create a massive maintenance problem for the county or city? This question of maintenance will be discussed further in Section 13 of this chapter.
2. What possible health hazards (mosquitos, rodents, trash, etc.) are associated with these facilities? Cobb County Health Department has expressed some concern about this matter. None of the areas studied have had enough of these facilities in existence long enough to obtain any information concerning health hazards.
3. Are there combinations of flood storages and storm patterns for which storage facilities will actually increase flood peaks?

The first two of these considerations were addressed in the quotations given earlier in this section. Thus many of the areas studied (Chicago, Tampa, Atlanta, Ingham and Fairfax Counties) have expressed

concern about using on-site storage facilities for all developments but have agreed that their use in some cases can be beneficial. Thus consideration must be given so that maintenance and health hazards are not created which might be more detrimental to the community than are the problems being solved.

The third consideration was investigated by Mr. Ormond C. White in a report entitled, "An Investigation of Downstream Effects of Limiting Peak Outflow from Subwatershed Developments" (64). In this study, Mr. White demonstrated that regulation of outflow from many small subwatersheds causes reductions in stream channel peak flows but the effect diminishes as the flood moves downstream. Mr. White also found that while the peak of the flood hydrograph is diminished by the use of storage facilities, flows during the recession period are higher. Thus, it is conceivable these higher recession flows could coincide with flood flows from subwatersheds downstream, to cause greater flood peaks than would have occurred without the use of storage facilities. As Mr. White points out in his study, it is important to analysis the effects of all proposed development and flood control facilities for the entire watershed (or several watersheds) rather than just for the development site under consideration.

On-site storage was included in the proposed model ordinance so that it can and will be used when it represents the best solution to a given drainage problem. Many of the areas studied have found that on-site storage is a sound engineering and economical solution to some drainage problems.

The City of Tampa has done some economic analysis of the use of

retention basins and their results show about a 20 percent savings by using retention basins rather than increasing the capacity of the sewer system to that which could handle the increased runoff. This analysis included the cost of the land since the City purchased the land, designed, and paid for the construction of these facilities. The City will also maintain these retention facilities. It should be pointed out that the retention basins constructed in Tampa are located within areas of the City where the price of land is relatively low.

Off-site storage was included to encourage the use of consolidated storage facilities while still protecting adjacent property owners. The County can play a major role in making this option attractive to developers by:

1. Constructing the storage facilities and prorating the costs among the developers benefiting (this will be discussed further in Section 10 of this Chapter - Cost of Drainage Improvements).
 2. Encouraging developers to cooperate with each other and construct common facilities that will benefit everyone concerned. Fairfax County's active participation in this area has resulted in the development of several major facilities.
- 9.3 *Improvements of Existing Drainage System - Improve the existing drainage system, without causing damage to upstream and downstream property or increase flood elevations beyond the vertical limits set for the flood plain district, to safely accommodate the increased runoff from the proposed development. Care must be*

exercised in utilizing this option so that the natural environment of the existing drainage system is not unduly harmed.

Commentary

Section 9.3 - Improve Existing Drainage System. Quoting from several of Fairfax County's policies concerning off-site drainage and use of flood plain areas:

It is recognized that some improvements must be made within flood plains, streams and/or drainageways in such a manner that the increased runoff from changes or improvements within the watershed may be accommodated without unacceptably elevating flood plain areas. This may take the form of stream bed clearing, removal of obstructions, reduction of constrictions, stabilization of stream bottoms and/or banks or areas to eliminate or reduce erosion, widening deepening or realigning of streams to provide the necessary hydraulic characteristics to accommodate the anticipated stormwater flow without damaging adjacent properties. These improvements should include removal of silt and debris which may clog or damage downstream drainage structures or property, the filling or drainage of ponding areas and stagnant pools which are potential vermin shelters and mosquito breeding areas.

In the interest of the health, safety and welfare of all, when the appropriate land use has been determined for any area to be developed, the County reserves the right to require the developer to show that off-site downstream drainage can be accommodated (considering the planned development of the contribution watershed) without damage to existing facilities or properties before such development is approved for construction.

Development within a watershed involving a change of land use therein, is normally associated with an increase in impervious areas resulting in a greater quantity as well as a more rapid and frequent concentration of stormwater runoff. The construction of storm drainage improvements will be required along waterways as watershed development progresses to alleviate flood damage and arrest deterioration of existing drainageways. The extent and character of such improvements shall be designed to provide for the adequate correction of deficiencies, and will extend downstream to a point where damages to existing properties ascribable to the additional run-off will be minimized.

The above policy statements from Fairfax County have recently been superseded by the County's new interest in detention storage. The above policies were interpreted by the County's personnel as requiring the installation of temporary storm water detention ponds only in areas where downstream storm drainage systems were not adequate to receive the increased run-off being generated by the upstream development, and definite planning was not available for improvement of the inadequate downstream drainage system. The County personnel have interpreted the new policies concerning storage facilities such that storm water retention-detention facilities be evaluated for all storm drainage plans proposed for development in the County that are submitted for review and approval.

Many of the persons interviewed in Fairfax County prefer the earlier statements where the existing capacity of the drainage system and flood plain district are utilized before storage facilities are required. Section 9.3 of this ordinance allows this capacity to be utilized by improving the downstream drainage system, as long as no property is damaged as a result.

9.4 *Flood Proofing - Financially compensate the owners of existing property which might be damaged by the increased storm runoff so that proper flood proofing can be accomplished. This option is only available where it can be shown that flood proofing will prevent damage resulting from the increased storm runoff and all owners of affected property are in agreement. To ensure that subsequent owners of the affected property are made aware of this agreement,*

the owners must sign a release from all flood damages resulting because of increased storm runoff from the proposed development. A copy of this release must be recorded with the deed to the property.

All proposed improvements must be approved by the County Engineering Department

Commentary

Section 9.4 - Flood-proofing. In some instances (probably in rural or undeveloped areas) it might be that only a few existing structures would be affected by an increase in flood waters. If it is more economical to flood-proof these structures, and agreeable with all parties concerned, than to control the increased run-off then this option should be utilized.

There are several administrative procedures that could be used to handle the financial arrangements necessitated by Section 9.4. The existing downstream property owner could receive a lump sum payment from the owner of the property being developed. As an alternative to this, the owner of the developing property could establish an escrow account to cover the expected flood damages to the downstream property owner. The details of whatever administrative procedures are recommended by the County should be contained in the County's Flood and Erosion Control Manual.

It should be remembered that using section 9.4 of this ordinance could result in flood waters exceeding the limits of the flood plain district. This would necessitate changing the limits of the flood

plain district.

In summary, Section 9.0 of this ordinance allows more flexibility in determining what drainage improvements are required for a given development than any of the ordinances studied. Tampa, Fairfax and Ingham County's ordinances were probably the most flexible of any of those studied.

In the interviews with consulting engineers from all of the areas studied, the consensus of opinion was that the design engineer should be allowed to express his opinion as to whether or not on-site storage should be used to solve the drainage problems within a given development. They felt that a blanket rule of on-site storage for every development was not a good solution to drainage problems because some sites may not have suitable areas for storage facilities and another solution might be much better from an engineering, economic or aesthetic viewpoint. Thus each development should be evaluated on a case-by-case basis rather than trying to formulate overall solutions for every drainage situation.

Section 9.0 of this ordinance gives the flexibility needed to arrive at the best solution for each drainage problem and at the same time protects all of the property within a drainage area from damages due to increased storm runoff.

Most of the drainage ordinances studied were written for urban areas where existing drainage problems had forced the City or County Governments into adopting the existing drainage ordinance. In many of these areas (especially Chicago) the options of improving existing drainage systems, limited flood-proofing, and off-site storage would be very expensive because of the vast amount of existing development which would

be affected. Thus on-site storage has become accepted as the best solution to drainage problems in these areas, or at least as a means of controlling the increased runoff from proposed developments so that existing drainage problem will not become worse.

In contrast, when rural or developing counties adopt a drainage ordinance all or some of the options listed are potentially feasible and each should be available and evaluated to obtain the optimum solution for a given drainage problem. Thus, this ordinance is applicable to both urban and developing areas.

Hydrologic computer simulation would be valuable in providing quick and accurate analysis of proposed on-site and off-site drainage facilities. Interrelationships between existing and proposed facilities could be easily and quickly analyzed. In addition alternative designs (proposed by the County or consulting engineers) could be analyzed.

Section 10.0 - Cost of Drainage Improvements

The following requirements will determine the proportioning of drainage improvement costs resulting from the proposed development.

1. If all the proposed drainage improvements are contained within and are solely for the benefit of the proposed development, then the total cost of these improvements will be borne by the developer of the proposed development.
2. If some of the proposed drainage improvements are not contained within the proposed development but are necessitated by and accrue benefits solely to the proposed development then the total costs of these improvements

will be borne by the developer of the proposed development.

3. If off-site drainage improvements are required as the result of more than one development then the costs of these improvements will be proportioned among the developers benefited. Computation procedures for prorating the drainage costs are given in the County's Flood Control and Erosion Manual.
4. If a developer wants to develop a portion of an area draining to a proposed off-site drainage improvement, before this improvement is constructed, he may use either of the following options:
 - A. construct the proposed off-site drainage improvement which will serve the entire area draining to this facility, or
 - B. provide the funds for the construction of this drainage facility.

This will allow the developer to proceed with the improvements of his land without damaging the properties of others (assuming, if option B is selected, the County constructs the drainage facility before improvements are made). The County will endeavor to collect, on pro-rata basis, any excess funds plus interest expended by this developer beyond his proportionate share of the cost of such improvements from future properties within the watershed served by such drainage improvements when such properties are developed within a period of ten years from the date that

the drainage improvements are financed or constructed.

These funds plus interest, if collected, will be turned over to the initial developer or his assigns.

5. *If the County chooses to provide drainage facilities, the cost of these facilities will be prorated and assessed as a development cost when and if development occurs on the affected lands within a ten year period.*

Commentary

Section 10.0 - Cost of Drainage Improvements. Only Tampa and Fairfax County's ordinances dealt with cost of drainage improvements. Tampa assesses the developers for needed drainage facilities according to the amount of runoff resulting from their development calculated as a percentage of the total runoff. Fairfax County states that the amount of impervious area may be substituted for runoff quantities. Any number of different pro-rata systems could be used but the details of prorating the costs should be contained in the County's Flood and Erosion Control Manual while the general policies of cost distribution should be included in the ordinance.

The reasons that the cost of drainage improvements are included in this drainage ordinance are:

1. This section states the policy of the County with respect to cost of drainage improvements.
2. As discussed in other sections of this chapter, the use of retention facilities in some of the areas studied has resulted in the proliferation of small ponds scattered around the County. This type of approach to flood control could

result in health and maintenance problems. Thus, in order not to infer that this ordinance encourages the use of numerous small facilities, this section establishes several specific ways that consolidated facilities can be funded by either initiation from private developers or under county direction.

3. Some system should be used whereby those that are affected and accrue benefits from specific facilities should also be the ones to pay the cost of these facilities rather than having everyone in the area pay the costs.

At the present time, Tampa's cost sharing system is voluntary but the city personnel report no major problems in obtaining funds from the developers. The developers contacted voiced approval of the system.

Fairfax County has designated certain areas of the County where pro-rata cost sharing is required. The County personnel anticipate that pro-rata cost sharing will be required for the entire County in the near future. These personnel report no major problems in the administration of this program.

Thus, the purpose and intent of this section is to require developers of land to pay their proportionate share of the cost of providing reasonable and necessary drainage facilities, located within and/or outside the property limits of the land owned or controlled by the developers, but necessitated or required, at least in part, by the construction or improvement of their development.

Section 11.0 - Erosion and Sedimentation Control

Proposed temporary and permanent erosion and sediment control

plans shall be submitted with each application for a development permit. These plans shall specify in detail the erosion and sediment control measures to be used during all phases of clearing, grading, filling, construction, and permanent development and accurately describe their proposed operation. In addition, these plans shall be in accordance with the latest specifications and recommendations as outlined in the County's Flood and Erosion Control Manual.

No clearing, grading, excavating, filling or otherwise disturbing natural terrain will be permitted until approved County erosion and sediment control measures have been installed except those operations needed to install these measures. All erosion and sediment control measures shall be continuously maintained during the construction phase of the development.

These erosion and sediment control measures shall apply to all features of the construction site, including street and utility installations as well as to the protection of individual lots.

Commentary

Section 11.0 - Erosion and Sediment Control. Except for Chicago all of the areas studied had some provisions for erosion and sediment control in their ordinances. These provisions ranged from Ingham County's statement that, "all disturbed soils shall be mulched, seeded and fertilized in a manner to prevent erosion," to a very elaborate erosion and sediment control program in Fairfax County. Fairfax's program included a detailed erosion and sedimentation ordinance and several accompanying publications including an Erosion-Siltation Control Handbook.

One of the major differences between Section 11 of this ordinance and some of the other ordinances studied (including Tampa, Fulton and Clayton Counties) is that the specific details of what erosion and sediment control measures should be used and the implementation of these measures are proposed to be contained in the County's Flood and Erosion Control Manual rather than in the ordinance. This is consistent with the emphasis in this thesis that the drainage ordinance should be a policy statement and not an engineering document.

There are many different erosion and sediment control methods and facilities that could be used with new ones being continuously developed. Fairfax County states that it keeps its Erosion-Siltation Control Manual in a draft form, "because of the amount of experimental work being done in urban erosion and siltation control and the continued difficulty in setting specific quality standards."

Specific controls can range from retaining natural vegetation to engineered siltation basins. Rather than trying to include a partial list of typical erosion and sediment control measures in the drainage ordinance, it would be better to adequately discuss the details and implementation of these measures in a separate document that could be continually updated. Then each development should be evaluated on a case-by-case basis and methods used to most effectively control erosion and siltation from that area.

Following is a brief discussion, based on the results of interviews in the areas studied, of the major proposals contained in Section 11 of this ordinance:

1. Temporary and permanent erosion and sediment control should

be an integral part of all developments. For small developments this might be simply placing hay bales around catch basins or retaining the natural vegetation to act as a filter and trap sediment from storm runoff. For large developments siltation basins, dikes, seeding programs, etc., might be required. The engineer and landscape architect should be encouraged to utilize those methods which will do the best job of controlling erosion and sediment from each development.

2. It is important to install proposed erosion and sediment control measures before any construction operations begin. It has been the experience in Cobb County that many developers will wait for a slack period during construction to install these measures. In many instances this is after the area has been cleared and graded and allowed to erode for an extended period of time.
3. Maintenance of erosion and sediment control measures is probably the most important aspect of any erosion and sediment control program and one of the most difficult to administer. Many of the control measures (basins, dikes, etc.) are designed to be continually maintained, especially after heavy rains, to insure that they operate as designed. However, none of the areas studied had adequate, if any, personnel to continually inspect development sites. The inevitable result is that these facilities become inoperative and do not function to control erosion and sediment as they were designed. This problem of maintenance will be discussed

further in Section 13 - Maintenance.

Erosion and sediment control of street and utility installations is very important. In Cobb County, there have been several instances where developers have cleared and graded roadway areas and have then stopped construction operations for several weeks allowing these areas to erode. Although quantities of sediment were never measured, large amounts of sediment originating from this road construction were deposited downstream (1-2 miles) resulting in considerable damage to property and existing lakes. Thus, it is important to emphasize in the ordinance that erosion and sedimentation control is needed for these operations. Tampa, Clayton and Fairfax Counties included some regulations for controlling erosion and sediment from street and/or utility installations.

Section 12 - Grading and Drainage Plans Required

Grading and drainage plans shall be submitted with each application for a development permit. The results of all hydrologic and hydraulic studies including the 100-Year Flood Contour Elevation must be clearly shown on all site plans where applicable. In addition, a soils investigation report to evaluate possible drainage and erosion problems may be required at the option of the County Engineer where he feels that unstable slopes or other site conditions warrant such a study.

A detailed discussion of information to be included in the above plans and reports is contained in the County's Flood and Erosion Control Manual.

Commentary

Section 12 - Grading and Drainage Plans Required. All areas studied required drainage and/or grading plans for proposed developments. Some areas excluded very small lots (1/4 acre or less) from the requirement of having to submit a formal plan and only required a sketch of the proposed drainage.

Tampa, Chicago, Fairfax and Ingham County's ordinances contained a large amount of detail pertaining to the scope and content of required plans. Following are some typical requirements contained in these ordinances:

1. required information to be shown on plans (e.g., contour intervals, channel profiles, utilities, street construction plans, drainage information),
2. requirements pertaining to approval and coordination with other governmental agencies and private utilities,
3. special requirements pertaining to drainage plans for small areas.

This type of information should be contained and discussed in detail in the County's Flood and Erosion Control Manual and not in the ordinance. This will provide more opportunity for a complete discussion of the many details involved and also allow for updating of the requirements without affecting the intent of the ordinance.

Tampa, Chicago, Fairfax and DeKalb Counties all required that the flood plain area be shown on the drainage plans. This provides a good graphical representation of the interrelationships between the proposed development and the flood plain area. In some cases this also

informs a developer or purchaser of the relationship between the property he is developing or purchasing and the location of the flood plain.

Only Tampa and Fairfax County required submittal of soil studies. Soil studies are probably not necessary for every development but could play an important part in evaluating certain drainage and erosion problems. Thus the County Engineer should have the option of requesting these studies and for public information the ordinance should contain some mention that such studies might be required. Many of the areas studied were covered by U.S. Soil Conservation Services Soil Survey studies which could be used in evaluation of drainage problems.

Section 13.0 - Maintenance

Any portion of the drainage system, including on-site and off-site storage facilities, that is constructed by the developer will be continuously maintained by the owner or owners subsequent in title of the affected lands unless it is officially accepted by the County Engineer for County maintenance. In addition, where debris or sediment has accumulated in such a manner as to interfere with the free flow of water or adequate functioning of drainage facilities, the County Engineer shall require the owner of such properties to clear and remove the debris or obstruction to permit the drainage system to function efficiently.

After notice and reasonable diligent efforts to have the owner of the property remove the debris or obstruction, the County Engineer is hereby authorized to enter upon such drainageways and clear or remove the debris or obstructions. The cost thereof shall be charged to the owner of the property where said debris and/or obstruction was generated. The County shall not charge such costs to the owners where the

debris or obstruction within the drainageway was not generated from his own property or caused by the owner's negligence or action.

If it cannot be determined from what property the debris or obstruction was generated, or if the debris or obstruction was not caused by anyone's negligence or action, then the County will arrange for its removal.

Commentary

Section 13.0 - Maintenance. The DeKalb County Drainage Engineer reports, and this sentiment was echoed in all of the areas studied, that the one major problem plaguing the Drainage Department, both in the application of the drainage ordinance and in the entire drainage program, is the problem of maintaining the drainage system.

In the areas studies, this problem of maintenance is handled in two different ways:

1. In Chicago, Ingham and Fairfax Counties, the County, Metropolitan Sanitary District, or local communities maintain the entire drainage system except for some large developments where the developer has agreed to maintain the system within these areas.
2. In Tampa and the Atlanta Metropolitan Area, the cities or counties only maintain those portions of the drainage system that are within the municipalities' right-of-way and those areas specifically accepted for county or city maintenance. The maintenance of the drainage system that is located on private property is delegated to the owners of the affected land.

Following are some problems which have been encountered with both of these approaches to maintenance of the drainage system:

1. In Chicago, Ingham and Fairfax Counties, the major problem is obtaining enough money and personnel to do an adequate job of maintenance.
2. In Tampa and the Atlanta Metropolitan Area it has proven very difficult and unpopular to get the owners of private land to adequately maintain the drainage system. In many cases the municipality has unofficially accepted the maintenance of portions of the system. Many of the persons interviewed in the Atlanta Metropolitan Area felt that in the near future the counties and cities would be accepting the maintenance responsibility of the entire drainage system.
3. Where the municipalities have accepted the maintenance responsibility for the drainage system, the construction of consolidated storage facilities is encouraged for ease of maintenance, among other reasons. In the Atlanta Metropolitan Area the majority of the storage facilities constructed have been small on-site facilities. This proliferation of small facilities will be difficult to maintain if and when the counties or cities accept the maintenance responsibility.
4. Of all the areas studied, only Ingham County had a systematic system of preventive maintenance of the drainage system. Most of the maintenance done in the other areas was done in response to specific complaints or for the alleviation of

known drainage problems. In most cases these areas did not have the personnel necessary to provide a system of preventive maintenance.

It is readily apparent that if a drainage system is not adequately maintained, it will not function as designed and the overall effectiveness of the system will be decreased. The persons interviewed in the Atlanta Metropolitan Area felt it is extremely difficult to administer a maintenance program that is dependent on private individuals to provide most of the maintenance. It has been their experience that when the maintenance responsibility is left up to private owners, little or no maintenance of the drainage system is done. Many of these people felt the County should accept the responsibility of maintaining the system to ensure that the drainage system will function adequately to protect the citizens from possible flood damages caused by obstructions in the system. It was also felt that if the County accepted the maintenance responsibility, then the entire drainage system would receive some maintenance. If the County accepts the maintenance of the drainage system then Section 13.0 of this ordinance would not be needed. This section was included for use in the Atlanta Metropolitan Area or other areas where the maintenance of the system is delegated to the property owners.

Section 13.0 of this ordinance was modeled after a similar section in DeKalb and Fulton County's ordinance. Following is a brief discussion of some of the provisions included in this section:

1. The first part of Section 13 states that the maintenance responsibility for that portion of the drainage system

contained on private property will be maintained by the owner of the affected property. As discussed above, this is the policy in Tampa and the Atlanta Metropolitan Area. It might add incentive for maintenance to make a property owner specifically liable for all damages inflicted on others because of his lack of maintenance. The legal implications of such an action would have to be investigated for each community. In addition, such an action could result in the following problems:

- a. Many times after a storm it is difficult to determine where debris or sediment originated. It would be even more difficult to determine whether lack of maintenance caused the debris and sediment to leave one person's property and damage another's.
- b. A small amount of debris from one property might not cause serious problems during a storm, but the accumulated effects of lack of maintenance by many property owners could cause significant damages. It would be difficult to appropriate these damages among all those responsible.
- c. It is often politically unpopular for the County to force property owners to pay for related flood damages, even if their lack of maintenance cause them. Many people feel that maintenance of drainageways is a County responsibility no matter what the ordinance states.
- d. The possibility of legal actions necessary to enforce

such a policy could be politically unpopular.

2. Because of the difficulty in getting individual property owners to adequately maintain their portion of the drainage system, it has been found in the Tampa and Atlanta area that at times it is necessary for the County's personnel to enter upon private lands to clear or remove debris or obstructions to insure the adequate functioning of the drainage system. Thus, provisions have been stated in Section 13 to allow personnel from the local County to perform this work and charge the cost to the owner of the property where said debris and/or obstruction was generated.
3. As contained in DeKalb County's ordinance the last part of Section 13 states that no one will be responsible for the removal of debris or obstructions not generated from his property or caused by his own negligence or action. In addition, when the source of debris or obstruction cannot be adequately determined, then the County should assume the responsibility for its removal. At no time should a property owner suffer damages as the result of the actions of others or from areas over which he has no control. Essentially this is the policy that Fulton and DeKalb County have followed.

Section 14.0 - Subdivision Plats

Proposed tentative and final subdivision plats located contiguous to or within the flood plain district shall not be approved except in accord with the following requirements:

- 14.1 100-Year Flood Contour Elevation - Each plat shall contain a notation clearly stating the 100-Year Flood Contour Elevations as approved and accepted by the County Engineer. This elevation shall be designated on the plat by a heavy contour line.
- 14.2 Minimum Lot Area - No lot shall be approved which has less than ____ percent of the minimum lot area as established by the applicable zoning district regulations above the level of the 100-Year Flood Contour Elevation.
- 14.3 Drainage Easement - Where a proposed subdivision is transversed by a watercourse, drainageway, canal or stream, appropriate dedication or suitable easement provisions shall be made to accommodate storm water and drainage through and from the proposed subdivision. Said dedication or easement shall conform substantially with the lines of said watercourse and be of sufficient width or construction, or both, as to be adequate for the purpose including access for maintenance. The specific details pertaining to the size and extent of dedications or easements are contained in the County's Flood and Erosion Control Manual.

Commentary

Section 14.0 - Subdivision Plats. Although the details and regulations pertaining to subdividing lands are usually covered in subdivision regulations, the requirements contained in Section 14.0 of this ordinance have direct interrelationships with the other sections of this ordinance, and clarify and strengthen the means of administering

the ordinance.

Section 14.1 - 100-Year Flood Contour Elevation. The subdivision plat is a map of a subdivision that becomes a part of public records of land division. Plats are filed as part of deeds in the County Registry of Deeds, in most states. Thus for public information, for both the initial purchaser of a lot and all subsequent purchasers, it is important to show how the 100-Year Flood Contour Elevation is related to each lot. This requirement is consistent with Fulton and DeKalb County's regulations.

Section 14.2 - Minimum Lot Area. Each lot approved should have a suitable building site above the 100-Year Flood Contour Elevation. Chicago's ordinance states that a "building site" must be provided. This seems somewhat arbitrary and some guidelines should be established. By establishing a percentage of the minimum lot area for each residential zoning classification, (a different percentage could be selected for each classification) some flexibility is allowed in establishing a suitable building site for each classification. This regulation is similar to Fulton and DeKalb's regulation where 50 and 70 percent respectively of the minimum lot area is used. Air rights or the use of areas over the flood plain district but above the 100-Year Flood Contour Elevation could be used to satisfy the requirements of this section.

Section 14.3 - Drainage Easement. In order to allow for adequate drainage and maintenance of the drainage system within a subdivision, it is important to designate those areas which will act as drainageways. By designation of these areas on the subdivision plats, purchasers of lots will be informed of the relationships between the drainage through

and from the subdivision and their lot. This regulation is consistent with most of the ordinances studied.

Section 15.0 Bonding

The Bonding requirements for subdivision and site plans shall include a cash escrow guarantee which would assure the County that emergency flood and erosion control measures could be taken by the County at the developer's expense if he did not initiate such action within such period as determined by the County Engineer. The amount of such bond will be determined by the County Engineer and will be held by the County until all drainage and erosion control measures have been accepted by the County.

Commentary

Section 15.0 - Bonding. This section of the ordinance assures the County that funds will be available to initiate emergency flood and erosion control measures. It was reported in several of the areas studied that situations have occurred where a developer will clear and grade a site and then, for financial or various other reasons, let it lie idle for an extended period of time. In cases like this, the County should have the financial means to install necessary control measures to protect other property in the area. This bonding requirement also gives the County some leverage to force a reluctant developer to install the flood and erosion control measures as approved, without going through long and costly legal action. Section 15.0 of this ordinance is consistent with the requirements contained in Fairfax and Ingham County's ordinances.

Section 16.0 - Repeal of Conflicting Ordinances

The following ordinances or parts thereof are hereby repealed:

Commentary

Section 16.0 - Repeal of Conflicting Ordinances. This proposed ordinance is designed to complement and supplement, rather than conflict and overlap with existing regulations. It is also suggested that the most restrictive regulations should prevail. However, if it is necessary to repeal earlier ordinances, it is recommended not to use a general repeal. Instead, the parts or sections that are in conflict with this ordinance should be specified in Section 16.0 after careful study by the attorney representing the local government and the County Engineer.

Section 17.0 - Violation and Penalty

Any person, firm, or corporation violating any of the provisions of this ordinance shall be deemed guilty of an offense and upon conviction thereof shall be punished as provided by (cite local law). Each day's continuance of a violation shall be considered a separate offense. The owner of any lands or parts thereof, where anything in violation of this ordinance shall be placed or shall exist, and any person who may have assisted in the commission of any such violation, shall be guilty of a separate offense.

In any case in which any land is or is proposed to be used in violation of this ordinance or adopted amendment, the legal counsel of the County may, in addition to other remedies provided by law, institute

injunction, abatement or any appropriate action or actions to prevent, enjoin, or abate unlawful use. In addition, upon a finding by the County Engineer that any provision of this ordinance has been violated, all development and building permits will be suspended until the violation has been corrected to the satisfaction of the County Engineer.

Commentary

Section 17.0 - Violation and Penalty. A very effective means of forcing developers to correct violations is the suspension of development and building permits. This usually does not involve the legal problems associated with prosecuting an offender. Especially in erosion and sedimentation problems, it is necessary to quickly rectify violations to prevent the damages that might occur during a long legal conflict.

Section 18.0 - Appeals

In case of dissatisfaction with an act or determination in the exercise of the authority granted herein to the County Departments charged with the administration of this ordinance, any person, firm or corporation shall have the right to appeal to (name of authorized board which handles appeals).

Section 19.0 - Effective Date

This ordinance shall be in full force and effect from and after its passage, approval, and publication as provided by law.

CHAPTER V

FORMULATING A DRAINAGE PROGRAM

Following is a brief discussion concerning several important aspects of any drainage program which have not been covered thus far.

Flexibility in a Drainage Program

One of the primary objectives interwoven throughout the previous four chapters is the premise that a drainage program should contain enough flexibility to allow the use of the best engineered solutions for given drainage problems. This type of approach introduces several problems which deserve some mention.

Administration of the Ordinance

As written, the ordinance in Chapter IV encourages the engineer to evaluate each drainage problem and try to devise an optimum solution for that problem. Also, the county retains flexibility in designating the limits of the flood plain district. Thus it is possible that different restrictions would be applied to different areas of the county. This will introduce several problems in administering the ordinance.

1. The county will have to hire sufficient qualified personnel to evaluate each development on a case-by-case basis.
2. In addition to studying the drainage within a development, the drainage interrelationships between all the developments within a watershed (existing and proposed) will need evaluation.

3. The county will need to develop the technical aids necessary to do the above evaluations.
4. The county should consider taking an active role in the design, operation, and maintenance of the drainage system.

All of the drainage programs studied, except some from the Atlanta Metropolitan Area, have "flexible" drainage ordinances as proposed in this thesis. These areas also have the resources and manpower necessary to evaluate all proposed developments. In the Atlanta Metropolitan Area the trend has been to write ordinances which are very specific and require all developments to use storage facilities to control drainage problems. Such ordinances might be considered "rigid" ordinances. It is easier to administer "rigid" ordinances because a standard set of rules can be developed and applied to all developments. This also allows the county to hire fewer personnel with less training to administer the drainage program than would be required to administer a "flexible" ordinance.

The major disadvantage of a "rigid" ordinance is that it tends to result in too much conformity in engineering designs. Each design problem involves certain aspects that are unique to a particular situation. It is difficult to take into account all of these unique aspects in formulating general engineering rules and criteria. In addition, design methods and procedures change with time while many of the provisions of the ordinances studied did not.

In many of the interviews conducted, questions were asked concerning the basis used for including different design and engineering criteria in drainage ordinances. The usual response was that these

criteria were adopted many years ago and had been accepted through the years by their continual use. Engineering criteria included in ordinances can take on the nature of being accepted by the fact that they are included in the ordinance or because they have been used for such a long time. Thus, adopting a "rigid" ordinance for administrative ease has advantages and disadvantages which should be thoroughly considered.

It can be concluded from this discussion that one of the initial steps in formulating a drainage program is to evaluate thoroughly the general policies and objectives to be sought by a drainage program, and specifically concerning this discussion, should a "flexible" or "rigid" ordinance be adopted. Certainly an evaluation of existing drainage problems, anticipated problems, and the economics involved in adopting a "flexible" or "rigid" approach to their solution would be important parts of any such evaluations.

It should also be remembered that adopting an ordinance without the resources necessary to enforce it can result in a serious erosion of the public's confidence in the county's ability to deal with drainage problems. This can greatly restrict the county's ability to obtain funds and personnel, which are subject to community and/or political approval.

In summary, approaching a drainage problem with a standard solution cannot be the basis of an effective drainage program. This opinion was shared by most of the personnel interviewed in all of the areas studied. These same people felt it was essential to have sufficient qualified personnel, both in the government entity reviewing proposed developments and in the private sector designing these

developments, in order to adequately assess all drainage problems. Although this does complicate the administration of the drainage program, many of the areas studied are continually moving away from standard solutions and incorporating more and more flexibility in their drainage programs.

It should be remembered that much of the ingenuity and imagination that could be used to solve drainage problems can be stifled by "inflexible" or "rigid" drainage ordinances.

County's Role in Encouraging Innovative Drainage Solutions

The author has concluded, based on his experience in Cobb County and as a result of this study, that the private engineering sector has not been particularly innovative in finding solutions to drainage problems. It seems the primary interest of the engineer, most likely spurred by pressure from developers, is to get development plans approved by the county so proposed construction can proceed. Many of the engineers interviewed stated that rigid county rules and regulations which must be followed in order to get plans approved discourage innovation. The engineers know it is much easier to get county approval for standard than for new or untried designs. As a result, if innovative and imaginative designs are going to be applied to drainage problems, it will be up to the county to take the lead and provide the climate necessary to encourage such designs.

In order for the county to accomplish the above, it will have to hire qualified personnel who can use their knowledge and expertise to propose, encourage, and efficiently review new and different approaches to drainage problems. The Chicago Sanitary District provides probably

the best example of the areas studied. They have employed a well qualified staff and have taken a leading role in much of the drainage work in their area (including development of a computer simulation model, model ordinance, and other technical aids). Many times those people who appropriate funds disagree with the need to hire sufficient qualified personnel and thus limit the effectiveness of a drainage program.

Technical Requirements

The adequate administration of the ordinance proposed in this thesis requires that the county have the technical aids necessary to adequately assess the effects of proposed developments.

The development and application of some computer simulation model, if not essential, would be extremely helpful in administering a comprehensive drainage program (the benefits to be gained from such a model were discussed in Chapter II of this thesis). Thus the proposed ordinance was written assuming that some computer simulation model would be used by the county in administering it. The ordinance could be adopted and implemented without the aid of computer simulation, but many sections of the ordinance dealing with the combined effects of several developments and changes in the limits of the flood plain district would be difficult to administer.

Field Inspection

Although it is relatively easy and inexpensive for a county to adopt a drainage ordinance as proposed in this thesis, it becomes much more difficult and expensive to administer the ordinance. Not only should the county anticipate the need to hire qualified office personnel to administer the ordinance but sufficient qualified field personnel

will be needed.

It was universally voiced in all of the areas studied that field inspection was one of the major problems in their drainage program. Both the quantity and quality of inspectors was far below what these personnel felt would be adequate to do a good job of implementing their drainage program. Adequate field inspection is especially essential in the area of erosion and sediment control. Unlike drainage, where final inspection can determine if the proper facilities have been installed, effective erosion and sediment control demands inspections of the construction site and continuous maintenance. Sediment ponds fill up, hay bale barriers get destroyed or moved, berms and other erosion and sediment control facilities get damaged or for some reason do not operate as designed. It has been the author's experience, which was verified in the areas studied, that unless construction sites are adequately inspected, needed repairs and maintenance to erosion and sediment control facilities are not done and these facilities quickly become ineffective.

In order to decrease some of the required inspection, some areas have been successful in using a system of spot checking construction sites with heavy fines for violating erosion and sediment control regulations (the City of Macon, Georgia has used such a system). None of the areas studied have used such a system nor have they strictly enforced their erosion and sediment control regulations.

Random sampling with stiff fines could encourage self maintenance by owners, require fewer inspections, and raise funds for the drainage program. Thus, in lieu of hiring a large staff of inspectors, some form of random sampling combined with fines, as provided by law, could prove

effective in enforcing a drainage ordinance. Personnel and resources available plus local political and economic conditions will determine, to a large extent, what administrative procedures are used in implementing the ordinance. Each community should adopt procedures which prove to be most effective for their particular conditions and circumstances.

Before any ordinance is adopted, the financial responsibility of providing adequate field inspection should be assessed and provided for. Getting drainage, erosion and sediment facilities designed and on the plans is an important part of the drainage program, but getting them constructed, operating, and maintained has proved to be much more difficult.

Planning Aspects of Proposed Urban Drainage Ordinance

The proposed drainage ordinance has several land use planning aspects that deserve mention. One question that should be discussed is, "Where should the proposed ordinance be applied in the planning process?" Should the ordinance be applied during the initial planning stages or not until specific development proposals are reviewed? The answer is, "The ordinance should be applied at several stages in the planning process."

The proposed ordinance states specific objectives related to a county's drainage program. These objectives should be incorporated in the county's overall planning program. The ordinance states specific land use policies (areas included in flood plain, uses in flood plains, special permits) which should be included in all land use planning efforts. Provisions of the proposed ordinance have specific consequences

with regard to the zoning process (improvements required, nonconforming uses, hydrologic and hydraulic studies, and those provisions related to land uses). These provisions should be taken into account when preparing zoning districts and when ruling on zoning changes and variances.

Thus, the proposed ordinance should be initially applied when formulating objectives and continue throughout the implementation of specific ordinances and plans.

In addition, the proposed ordinance, combined with computer simulation, will provide the means necessary to anticipate and plan for the consequences of specific actions. The proposed ordinance specifically requires the evaluation of drainage effects on-site, upstream, and downstream from a proposed development. By evaluating drainage consequences of different development and land use patterns, planners will be able to recommend specific land use and policy decisions relating to existing and future developments.

Legal Considerations

Before any county adopts a drainage ordinance, the county's legal staff should review the ordinance to ensure that it does not conflict with local or state laws. As part of the review process that this thesis received, Mr. Steve M. Bull of the legal staff of Black, Crow and Eidsness, Inc., Engineers, reviewed and commented on the proposed model urban drainage ordinance in Chapter IV. This review resulted in several wording changes throughout the ordinance, to clarify certain terms and concepts. Also, Section 2.0 - Definitions - was added for additional clarification.

The major concern expressed by Mr. Bull was that counties would

be reluctant to accept the liabilities and responsibilities associated with adopting the proposed model ordinance. As discussed in several previous sections of this thesis, this is a major concern which should be thoroughly evaluated before a county adopts any drainage ordinance.

Other than the above comments, Mr. Bull found no other legal problems associated with the proposed model urban drainage ordinance.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

As discussed in the introduction, there are four goals for this study. A concluding discussion on the fulfillment of these goals follows.

Development of a Drainage Ordinance

The first goal was to develop a drainage ordinance based on the experience of the personnel within the areas studied, existing ordinances, author's personal experience, and current literature concerning urban drainage ordinances. Such a drainage ordinance was developed and is presented, in detail, in Chapter IV.

Several problems were encountered during the development of this proposed ordinance. At first, it was anticipated that specific provisions of the different ordinances studied could be evaluated by relating them to specific "hard data" (e.g., flood damages, maintenance records, drainage complaints). It was quickly realized these data were either unavailable or in a form which did not allow comparisons between areas. This lack of data hampered any comparison of drainage problems before and after adoption of an ordinance. In the areas studied where a drainage ordinance has been in effect for several years, periodic changes in the provisions of these ordinances have taken place with little documentation as to why changes were made and what effects resulted.

Thus, the major problems encountered were associated with the lack of hard data. As a result, personal opinions, broad interpretations of available documentation, general reactions of persons interviewed, inferred objectives and information were used to evaluate ordinance adequacy and effectiveness. In order to remove as much ambiguity and misinterpretation as possible, the above information was compiled into case studies which were then reviewed by several persons from each area, to validate the accuracy of the material. A review of the references given at the end of each case study in the Appendixes shows that a large and diverse number of people had input. As a result, these studies provide a good data base for documenting the proposed ordinance.

Thus, the first goal of this study was fulfilled and a model urban drainage ordinance was developed. The adequacy and effectiveness of this proposed ordinance will only be known when a county or city adopts it and assesses the results obtained.

Use of Technical Information

The second goal was to investigate the use of technical information in drainage and erosion control ordinances. In reviewing the ordinances from the study areas, it was found that many of them contain a considerable amount of technical information (e.g., hydrologic procedures, engineering standards, technical specifications). During the interviews, questions were asked relating to why some particular item of technical information was included and how often it was updated. It was found in most cases the reasons or basis for including the information was not known and little or no updating had been done. In many

cases technical information was accepted as being correct because of its inclusion in the ordinance and its use through the years.

In developing an erosion and sediment control program in Fairfax County, a manual was prepared which contained technical information pertaining to the administration of this program. The personnel in the County felt this was the best approach to keeping the technical information relevant and up-to-date without continually drafting new ordinances.

It is concluded that separating the technical information from the ordinance is advisable. This information should be contained in a separate document or documents. Thus, the second goal of this study was fulfilled by suggesting the inclusions of a Flood and Erosion Control Manual as a companion document to the proposed model urban drainage ordinance.

Computer Simulation Study

The third goal was to document the use of computer simulation in the DeKalb County Drainage Project and relate this work to the proposed drainage ordinance. The adequate administration of a drainage ordinance, as presented in this study, depends on advanced engineering techniques. Hydrologic computer simulation is such a technique and its application in DeKalb County relates directly to many of the provisions of the proposed drainage ordinance. The documentation of the computer simulation study in DeKalb County brought out some of the basic concepts involved in simulation and how they can be applied in administering a drainage program.

Hydrologic computer simulation can provide quick and accurate

evaluations of many drainage alternatives, evaluation of upstream and downstream effects of a proposed development, evaluation of complex arrangements of drainage structures, and evaluation of the water balance throughout a watershed or several watersheds. Thus, many of the provisions of the proposed urban drainage ordinance relating to the hydrologic and hydraulic effects of a proposed development would be easier to administer with the aid of hydrologic computer simulation.

Since the DeKalb Study will not be completed and the computer model operational until after this study on urban drainage ordinances is completed, it is not possible to document the application of the model by DeKalb County. Many questions such as operational costs, acceptability of the model results by County personnel, private developers and engineers, problems County personnel have in using the computer model, etc., cannot be answered until the model has been in operation for some time.

However, in Ingham County, Michigan, where a similar simulation study was done, the County is making routine use of the computer model to deal with these kinds of problems.

Objectives and Problems of Urban Drainage Programs

The fourth goal was to discuss the objectives and problems of urban drainage programs. This goal was the least fulfilled of the study goals because of the lack of available information concerning the objectives and problems associated with the urban drainage programs studied. Many of the areas studied have only recently adopted a drainage ordinance. Thus, it is too soon to evaluate many of the problems involved in administering it. The information that was obtained

concerning objectives and problems associated with the drainage programs studied, was used to document several of the provisions of the proposed ordinance and the discussions included in the first part of Chapter III and Chapter V.

In summary, this study of experiences, ordinances, and procedures of several urban drainage programs has provided a good base for proposing an effective urban drainage ordinance that can be adopted by both urban and urbanizing areas.

Recommendations

In drafting a model drainage ordinance it is difficult to take into account all the different local conditions. As an example, consideration should be given as to how much one can regulate flood plain land use before regulations begin to unduly limit the economic welfare of the county. The proposed ordinance might be too restrictive in an area like Galveston, Texas, where flood plains are very large, though it might be quite appropriate for Atlanta, Georgia, where flood plains are far apart and quite small. Thus it is recommended that before the proposed ordinance is adopted, each of the nineteen provisions outlined in Chapter IV be evaluated in terms of local conditions.

Several provisions of the proposed ordinance (statement of objectives, flood plain district uses, and special permits) contain lists of typical items that might be included within such a provision. It is not intended that all the items listed should be included in a local ordinance or that other items would not be appropriate. The list is given as a guide for a community to use in determining what items they will include. As an example, the proposed ordinance lists eighteen

objectives in Section 3.0. Some communities may prefer to limit the objectives to a few specific ones that pertain to local conditions while others might prefer a broader program. Local needs and political factors will greatly affect these kind of decisions.

Should the 100-year flood be used as the basis for all flood and drainage ordinances throughout the United States or would it be better to determine by economic analysis which design flood would be appropriate for a given community?

Because of recent rules and regulations established by the United States Federal Government, as part of their flood insurance program, the 100-year flood is being accepted as the basis for all flood and drainage ordinances. In line with this, the 100-year flood was used as the basis for the proposed ordinance. This is an area where more research and study is needed. In contrast to using a standard design flood for all areas, if an economic analysis approach, based on associated costs and benefits, were used it would then be possible for different communities to use different design floods as the basis for flood plain delineation. Thus local conditions would determine what design flood should be used. This might complicate the administration of the drainage program, especially the interrelationships between different programs in the same geographical area, but conformity also has its disadvantages. Further research in this area is needed before the 100-year flood becomes so standardized that it will be almost impossible to change.

Lastly, if a community plans to evaluate the effects of their drainage program, some systematic data collection system should be initiated. Records documenting changes in the drainage program,

drainage complaints (including severity and frequency), flood damages, etc., would be very helpful for future evaluations. A systematic collection of such data had not been done in any of the areas studied, which limited evaluation of the drainage programs.

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APPENDIX A

ATLANTA, GEORGIA METROPOLITAN AREA

The Atlanta Metropolitan Area is situated in a geographic province called the Piedmont Plateau in northwest Georgia. Atlanta lies at an elevation of around 1000 feet above sea level. The City of Atlanta is built upon a series of connecting ridges, called the Peachtree Divide. The eastern and southern sides of the urban area drain to the Atlantic Ocean through the South River, which is part of the Ocmulgee-Altamaha River system. The southern tip of the divide drains to the Flint River, while the western side drains directly into the Chattahoochee River (Figure A-1). The Flint and Chattahoochee Rivers meet at the Florida border to form the Apalachicola River which empties into the Gulf of Mexico.

The topography of the area is hilly with elevations varying from 740 to 1,680 feet above mean sea level. The high elevations are representative of the tops of several dominant geologic features such as Stone Mountain and Kennesaw Mountain, and are not typical of the otherwise rolling countryside. The maximum elevation, excluding these features is on the order of 1,250 feet above mean sea level.

The region lies in the Piedmont Plateau which is underlain with deeply weathered crystalline rocks. Along the Chattahoochee River, the surface is rugged and extremely hilly, as is the case also in portions of the Yellow and Etowah River Basins.

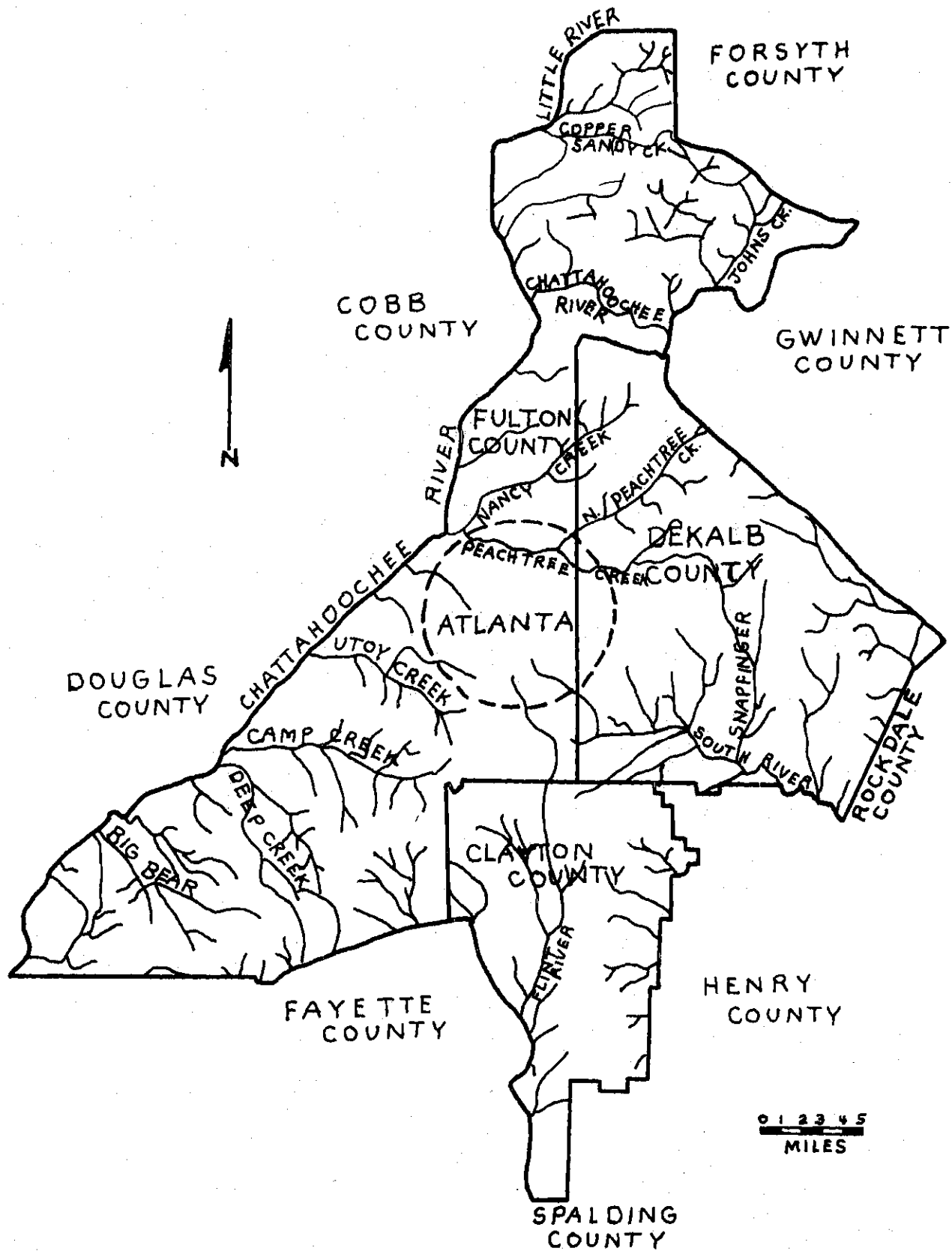


Figure A-1. Atlanta, Georgia and Vicinity - Major River Patterns

The Atlanta Metropolitan Area is essentially one of abundant rainfall. The average annual rainfall is about 52 inches per year (1). As a consequence of the abundant rainfall, annual runoff from streams is high. Average annual runoff from the watersheds in this area range from 15 to 24 inches per year (1).

Following are the four case studies for the City of Atlanta, DeKalb, Fulton, and Clayton Counties. These were the areas in the Atlanta Metropolitan Area which agreed to participate in this study.

City of Atlanta

City of Atlanta Drainage Program

With several of the Atlanta Metropolitan Counties actively engaged in developing their drainage programs, the City of Atlanta is taking a long hard look at its own drainage program to determine whether or not it is effective in dealing with present and anticipated drainage problems. The City of Atlanta has a Flood Control Ordinance dated 1963 and several provisions of its 1967 Rules and Regulations Governing Private Development of Sanitary or Storm Sewers deal with drainage. The City has also adopted Soil and Erosion Control Regulations pertaining to the grading of land.

Following is a discussion of the City of Atlanta's drainage program and some proposed changes.

City Personnel Dealing with Drainage. The City of Atlanta's drainage program is administered by the Public Works Department, under the direction of the Private Development Coordinator and his assistant. They review all development plans and drainage studies, and the Private Development Coordinator did most of the work in drafting the City's

drainage regulations. At the present time neither the Private Development Coordinator or his assistant are graduate engineers. They are, however, long-time employees of the Public Works Department with many years of practical experience dealing with drainage problems.

Recently the City has required retention storage facilities for several developments. The hydrologic and hydraulic studies done for these facilities were reviewed by a graduate engineer from the City's Engineering Department.

The City of Atlanta's Planning Department has had very little involvement with the City's drainage program. The Planning Department's activities, dealing with the drainage program, have been limited to reviewing the draft ordinances and regulations which were prepared by the Public Works Department.

Formulation of Goals and Objectives. In reviewing the City of Atlanta's publications pertaining to drainage, and interviewing the City personnel who work with and enforce the drainage program, it was found that there are no stated goals or objectives for this program. In addition, several of the persons interviewed stated that whatever drainage program now exists has evolved through the years and no one has ever stated any goals or objectives for the program.

Current Level of Service. As part of their drainage program, the City of Atlanta provides the following services.

1. Review plans for approval of development permits (taking into account zoning and subdivision regulations), inspect work for compliance during construction, and make on-site inspection and review of "as built" drawings for final acceptance of work.

2. Provide emergency response to flooding situations, rendering such assistance as is necessary and possible to minimize hazards to life and property.
3. Provide technical assistance to the residents of the City to help alleviate drainage problems.
4. Maintain function of existing drainage structures and facilities specifically accepted for City maintenance; repair, modify or replace existing obsolete structures to extent of capability. Following are some of the services the City has rendered in this area.
 - A. In some cases, if a citizen wants to have storm sewer pipe installed, the City will install the pipe if the citizen will purchase it.
 - B. The City will remove major blockages from watercourses that are beyond the means of the private citizen (large trees, automobiles, etc.).
 - C. The City does some debris removal along major watercourses.

Methods Used in Drafting Atlanta's Drainage Regulations. The City's existing rules and regulations pertaining to drainage, flood control and sediment control were drafted by the Public Works Department. The Planning Department reviewed these documents before they were adopted. These documents are based on the City's experience with their drainage program and the regulations and ordinances that have been adopted by the local metropolitan counties.

Provisions of the City of Atlanta's Regulations. The City has

several regulations pertaining to drainage and related areas. Following is a brief discussion of these regulations.

1. Rules and Regulations Governing Private Development of Sanitary or Storm Sewers - These regulations require submittal of plans showing flood elevations (based on the 50-year flood), specifies what hydrologic methods are to be used for storm sewer design, gives specific drainage and flood design criteria, and regulations pertaining to grading.
2. City of Atlanta's Flood Control Ordinance - This ordinance establishes a 50-year flood plain and lists the limitations on development within these flood plain areas. (Recently the City adopted the use of a 100-year flood plain.)
3. Ordinance to Regulate the Grading of Land Within the City of Atlanta - This ordinance specifies the conditions under which a grading permit would be needed, plans required, pollution restrictions, drainage standards to be followed when grading, and requirements for retention of mud and debris.

Hydraulic and Hydrologic Studies. The City only requires hydraulic and hydrologic studies when they feel there is a specific need for them. This decision is made by the Private Development Coordinator. In the past, studies were done only if the Private Development Coordinator felt a serious drainage problem might result from the proposed development. Recently the required on-site retention facilities have necessitated detailed hydraulic and hydrologic studies.

Drainage Plans. The Public Works Department requires a drainage plan for developments of one acre or more or where the Department feels

there is a potential for drainage problems. Where development is near or in the flood plain, the major requirement of the Public Works Department is that the cut and fill in the flood plain be balanced so that no storm runoff storage is lost due to filling within the flood plain.

Flood Plain Area. Until recently the City used the 50-year storm as the design storm for determining the flood plain areas. The Corps of Engineers has now revised their flood plain studies for the City so that they are now based on the 100-year storm.

Regulating Utilities in the Flood Plain. The City does not have any regulations controlling the installation of utilities within the flood plain areas. It was estimated by the Superintendent of Sewer Maintenance and Construction that approximately 500 utility crossings are above the normal water surface but still within the flood plain. He also commented that each spring several of these installations are damaged by flood waters causing a serious pollution and maintenance problem. In addition, during high water stages these facilities catch debris and interfere with the free flow of storm runoff.

Dumping in the Flood Plain. The City does not have any regulations controlling dumping in the flood plain. The only basis they have for control is that the dumping operation cannot restrict the flow of storm runoff or change the direction of the natural drainage.

Sediment and Erosion Control. The City's only regulation for sediment and erosion control is contained in the Ordinance to Regulate the Grading of Land Within the City of Atlanta, as previously discussed. On several developments the Public Works Department has required the developer to use hay bales in an attempt to control a specific erosion

problem but according to the Public Works Department, these facilities did not function adequately. In addition there are no requirements to insure the removal of the hay bales and deposited sediment after the development is completed.

Drainage Complaints. Due to a recent move in offices, the Chief of Consumer Services for the City informed me that many of the records of drainage complaints were misplaced and unavailable at this time. As a consequence he was only able to reconstruct the record of drainage complaints for a short period of time during 1972, but felt that this was representative of the magnitude of complaints the City received during the late summer and fall of each year. During the spring of the year when there is more rainfall, there is usually an increase in the number of complaints.

Record of Drainage Complaints - 1972
(July 1, through December 31, only)

1. Total number	205
2. Number investigated	205
3. Number required maintenance by City . . .	101
4. Number required installation by City with pipe furnished by owner of property .	38
5. Number private problems (those drainage problems located on private property and not subject to city maintenance as determined by the Public Works Depart- ment)	66

Thus, the City received about 35 drainage complaints per month during this period.

Concluding Remarks

The City of Atlanta's drainage program has evolved through the

years to respond to the problems and needs of the community. At the present time the City maintains more of its total drainage system than any of the metropolitan counties.

Recently there have been several major additions to the City's drainage program in the areas of on-site retention, grading of land, and sediment and erosion control. The City Public Works Department is taking a cautious approach to the inclusion of on-site retention into their drainage program. The Public Works Personnel feel that at the present time it is best to examine the effectiveness and feasibility of on-site storage for each individual development rather than requiring storage for all developments. If it is determined that these facilities do function as designed and lessen drainage problems, then the City will consider an ordinance to require on-site retention for all or most development.

In the areas of grading of land, sediment, and erosion control, the Public Works Department is just beginning to formulate its program for the implementation of these measures.

DeKalb County

DeKalb County's geography is such that almost all of the lands constituting the drainage basins of the streams within the County lie within the County's boundaries. The Drainage Department has divided the County into some 39 distinct drainage basins which lie wholly in the County or have their upper reaches within the County. Only the north fork of Peachtree Creek and the South River have any significant contributing areas outside the County. Six of the County's watersheds drain

to the Chattahoochee River, which flows into the Gulf of Mexico. The rest drain via the South River and Yellow River to the Ocmulgee River and ultimately to the Atlantic Ocean. DeKalb County, like all of the Atlanta Metropolitan Counties, does not have jurisdiction over drainage in incorporated areas within the County.

Extent of Drainage Problem

With the passage of the DeKalb County Zoning Ordinance of 1970, the Intermediate Regional (100-year) Flood Plain was designated as a drainage easement. Prior to this ordinance approximately 600 residences were constructed within these areas, and all of these residences will experience flooding to some degree if the 100-year storm occurs. There are also some small commercial, industrial and multi-family developments that are affected by the 100-year storm. In addition to this threat from a major storm there are approximately 200 residences that have been constructed at such proximity to the streams that they are generally flooded to an appreciable degree every year. The DeKalb County Drainage Department reports that this flooding is the principal problem resulting from major stream overflow. To keep this problem in its true perspective, it should be noted that there are some eighty thousand single family residences in DeKalb County which have experienced no flooding problem, so the homes affected by major stream flooding constitute approximately one fourth of one percent of the total.

During the year of 1972, DeKalb's Drainage Department received 2,375 reports of drainage problems. Of this number, 2,080 had been investigated and evaluated at the end of the year. These investigations revealed that about 60 percent of these required only routine maintenance.

This routine maintenance consisted of cleaning out debris and sediment from catchment basins, street gutters, culverts, and stream channels. Another 30 percent of the drainage problems were "classified" as private problems since the deficiencies were on private property or within the dedicated public drainage easements, but not specifically accepted for County maintenance. DeKalb County requires that the following statement be placed on each subdivision plat as a condition for its approval:

DeKalb County is not liable or responsible for the extension of the cross drains shown on property or for erosion or flooding of storm drains. The County will not be held responsible in anyway for flooding of this property from high water in the natural creeks and rivers and further the seller shall see that the above notation shall be recorded in deeds of conveyance to purchaser of each and every lot in this subdivision.

In effect, this statement restrains the County from entering or maintaining drainage areas, since such action might establish a precedent for continuing County responsibility. The practical application of this statement of responsibility appears to conflict with the responsibility (and legal authority) of the County to ensure the free flow of the drainage system.

The remaining 10 percent of the drainage problems were accepted by the Drainage Department as the unquestioned responsibility of the County to correct. These problems were either confined to the areas specifically accepted for maintenance by the County or were caused by some structural inadequacy of the existing County drainage system.

It has been reported by DeKalb's Drainage Department (in a report entitled, "Drainage Improvements Program", by the Planning and Roads and Drainage Departments, April, 1973) that these cases of localized

flooding have generally resulted from two major causes.

1. Inadequate design and installation of the drainage system by the original developer allowing high velocity discharges to rush through unlined ditches of exposed highly erodible soils. The results range from unsightly trenches to canyons with potholes of standing storm water providing an undesirable environment and breeding ground for mosquitos and snakes. In addition, the transported sediment continues to be deposited in downstream drainage structures and stream channels, which are already taxed to capacity.
2. Rapid and extensive creation of impervious areas throughout the County, have resulted in increased runoff from these drainage areas.
3. Although not included in this report, inadequate design by those constructing the original downstream features of the drainage area (bridges, culverts, etc.) have also caused localized flooding.

Man-Made Complications. One part of the drainage problem is the physical constraints to the free flow of storm water. These complaints may be classified into two categories:

1. those caused by design,
2. those caused by negligence.

In the first category, the principal impediments to the flow of water are found in culverts and bridges designed with insufficient or poorly aligned openings, and in sanitary sewer or water lines across stream channels within the levels normally occupied by the flowing streams.

In addition, drainage pipes allow surface waters to be drained through property and beneath public streets and then deposited into natural drainage ways. Problems can arise when the discharge from these pipes erodes the soil and stream bed adjacent to the pipe outlet. Inlets to drains can also be eroded causing drainage problems. DeKalb County

reports that they have encountered all of these problems within their drainage system. The County regulations do not specifically regulate construction of utilities, sewers, and other crossings that often obstruct flows.

The second category includes the accumulation of debris within the stream channels. This debris generally includes tree branches and foliage, automobile tires, household appliances and other discarded litter. DeKalb's Drainage Engineer has reported that these obstructions usually cause only minor suppressions of the stream flow. However, this debris has accumulated at points where fixed structures cross the stream channel creating a dam which impounds the stream flow and creates "artificial" flooding upstream at levels and frequencies not directly related to hydrologic factors.

Erosion and Sedimentation. From the standpoint of cost of correction this is probably one of the most significant drainage problems facing the County. Sediment consists of soil particles, organic material, and insoluble nutrients conveyed and deposited by surface waters. Unregulated urban development can result in increased soil erosion which is one major source of sediment. This sediment occupies space within the channel intended for flowing water so the water is forced to seek a higher level, which is frequently across the yards and in the buildings adjacent to the streams.

Amounts of sediment vary from stream to stream and are difficult to measure. However, the DeKalb County Drainage Department reported that since 1963, both the north and south forks of Peachtree Creek have collected at least one foot of sediment. Such deposits reduce a stream's

capacity to flow and retain flood waters and thus contribute to flooding.

DeKalb County Drainage Program

In 1970 the Federal Insurance Administrator announced the formation of a new two year emergency flood insurance program, authorized under the emergency flood provisions of the 1969 Housing and Urban Development Act. Under this emergency program, residents of communities which meet Federal requirements for land-use and land management practices that will reduce future damages from floods can obtain flood insurance without waiting for time consuming actuarial studies to establish insurance premium rates. To qualify for this insurance a community is obligated to assist the Federal Government in identifying specific flood hazard areas and to give assurance that they will enact appropriate zoning regulations, building codes, and other measures to eliminate or minimize damage from future floods.

DeKalb County's government quickly qualified for this program. The Planning Department prepared a comprehensive report as required under the program. The Board of Commissioners adopted a resolution establishing the need for such a program in the County and by the end of March 1970, the official application had been submitted.

On July 14, 1970, the Board of Commissioners passed an interim drainage ordinance to place in effect the proposals made under the Flood Insurance Program. This ordinance was later incorporated into the comprehensive Zoning Ordinance of 1970. Subsequently, the wording was revised to clarify some sentences where the intent was unclear. On June 11, 1974, minor changes were made in this drainage ordinance and it was

then incorporated into an environmental ordinance. As of May 31, 1974, there have been 461 flood insurance policies sold under the Flood Insurance Program in the seven county Atlanta Metropolitan Area (City of Atlanta, Fulton, DeKalb, Cobb, Clayton, Gwinnett, Rockdale, and Douglas).

DeKalb County has stated that the objective of their drainage ordinance is, "to prevent the continuation of irresponsible development and to encourage development appropriate to land use, competently planned and executed so as to produce a genuine asset to its owners and to the community as a whole."

The major provisions of the environmental ordinance dealing with drainage, and designed to contribute to this end are as follows:

1. Classification of the Flood Plain Drainage Easement,
2. Requirements for Plans and Hydraulic Analysis,
3. County Development Standards (grading, erosion and sedimentation control, vegetation, and drainage),
4. Information Required Pertaining to Drainage and Sediment Control.

Specifically this ordinance establishes a flood plain based on the 100-year storm, requires hydrologic and hydraulic studies and retention facilities for all developments which increase storm runoff by more than one cubic foot per second during a ten-year frequency storm, establishes conditions for consolidation of storage facilities, establishes development standards for flood plain areas (including filling flood plain areas), requires erosion control plans, establishes special standards for single family residential areas, states bonding or other requirements, indicates maintenance responsibility, and states the

County's policies of enforcement and administration.

Administration. The DeKalb County Planning Department has been designated as the official regulatory body to coordinate and enforce all flood plain management.

The Director of the Roads and Bridges Department has been designated as the approval authority for all grading and drainage plans. This Department has seven engineers working with drainage related problems.

Long Range Goals of the Program. The DeKalb County Drainage Department has stated the long range goals of the drainage program to be the following:

To effect, regulate and control the construction and maintenance of adequate facilities for the collection, temporary storage, conveyance, and disposition of storm waters entering or falling within the boundaries of DeKalb County's drainage jurisdiction; and to preserve and improve environmental quality in the process.

Current Objectives. The DeKalb County Drainage Department has listed six current objectives of the drainage program as follows:

1. Develop a comprehensive plan to handle storm run-off safely and efficiently, conforming to methods which are economically feasible and environmentally acceptable.
2. Regulate development so as to prevent an increase in run-off rate from the development site, to prevent the reduction of flood plain storage of storm waters, to prevent improper use of the natural flood plains, and to prevent downstream damage from site generated water-borne silt and debris.
3. Minimize adverse hydraulic effects of stream crossings by sanitary sewer lines, water mains, etc., through plans review and coordination with responsible agencies.
4. Minimize the infiltration of storm waters into the sanitary sewer system and the overflow of sanitary sewers into the storm drainageways, flood plains, and streams.

5. Utilize appropriate public open space for both recreational use and the temporary storage of excess storm waters.
6. Develop an adequate program for maintenance and improvement of existing drainage facilities.

Current Level of Service. The DeKalb County Drainage Department has delineated their current level of service under their drainage program as follows:

1. Compile and maintain an inventory of existing drainage structures denoting location, type, size and condition throughout the County drainage jurisdiction.
2. Review plans for approval of development permits, inspect work for compliance during construction, and make on-site inspection and review of "as built" drawings for final acceptance of work.
3. Investigate, evaluate, and prepare engineering solutions to existing drainage problems.
4. Provide emergency response to flooding situations, rendering such assistance as is necessary and possible to minimize hazards to life and property.
5. Maintain function of existing drainage structures and facilities specifically accepted for County maintenance; repair, modify or replace existing obsolete structures to extent of capability.
6. Introduce and encourage innovative design and methodology to better achieve program objectives with emphasis on safety, simplicity and environmental impact.

The County is anticipating that the Hydrologic Computer Simulation Study now being conducted will provide them with the technical tool necessary to effectively carry out the above services.

Methods Used in Drafting DeKalb's Drainage Regulations. The 1970 Drainage Ordinance was primarily drafted by the Drainage Engineer and then reviewed by other County Departments and representatives from local interest groups. Recently the County has revised this ordinance and

incorporated it into an Environmental Ordinance. This Environmental Ordinance was drafted primarily by the County Planning Department with considerable input from other County Departments and local special interest groups. Also several public hearings were held to get citizen input into this ordinance.

Hydrologic Studies and On-Site Storage. One of the major purposes of the DeKalb County drainage requirements is to require the developer to supply storage for any increased runoff that his development produces (for a ten-year frequency storm). Thus hydrologic studies are required for all developments within the County except for the development of a single residence.

Problems and Results Obtained from Application of DeKalb's Ordinance. The DeKalb County Drainage Engineer reports that DeKalb's Drainage Ordinance is a valuable tool but it is too early to assess its overall effect. He states that the contractors and developers have accepted the restrictions as outlined in the ordinance and actually very few problems have resulted. One reason for this lack of problems could be that the Drainage Department has conducted several workshops in which the drainage ordinance was explained and also the contractors and developers had the opportunity to ask any questions they had on the application of the ordinance. Another reason may be that DeKalb's flood plains are small and far apart.

The one major problem that has plagued the Drainage Department, both in the application of the drainage ordinance and in the entire drainage program, is the problem of maintenance of the drainage system. It has always been the policy of the County that they will only maintain

that part of the drainage system located on County owned land and streets. The remainder of the system is to be maintained by the individual property owners. The Drainage Department reports that in many cases this maintenance by individual property owners has not taken place and as a result the free flow of the drainage system has been impaired.

Another problem that has been encountered in DeKalb County is that of inspection during the construction phase of the development. In many cases the consulting engineer that is hired to design the system does just that, he designs the drainage system and then never sees the project again. Another engineer, usually employed by the developer, signs the as-built drawings. Especially in the control of erosion and sedimentation, when the construction phase is very important, some sort of continued inspection by the design consultant might be needed. If a system is to be constructed according to a certain design, some inspection is usually required.

Concluding Remarks

While most counties and cities are still talking about their drainage problems and possible solutions, DeKalb County has taken bold steps in the direction of solving its problems. With very little time and few resources they drafted a drainage ordinance several years ago which attempted to deal with the drainage problems within the County. Since then they have spent much time and effort revising this ordinance. The philosophy that the County has adopted in dealing with its drainage problems is that means should be provided at each development to control the increased runoff generated by that development. Thus the County has attempted to solve the problem at its source and not pass it downstream.

This might be thought of as a "decentralized" approach to solving drainage problems as contrasted to a more "centralized" approach of using large areas as detention storage for several developments. At the present time, each development is considered independently from the other developments within the County, although the hydrologic computer simulation study will provide the County the means to investigate the interrelationships between developments.

Fulton County

Fulton County is divided into two separate areas, North Fulton County and South Fulton County, with the City of Atlanta located in-between. The Planning Department has divided the County into some 36 distinct drainage basins with 21 located in North Fulton County and 15 located in South Fulton County. Many of these drainage basins have their upper reaches located within the adjacent counties of DeKalb, Gwinnett, Forsyth, Cobb and Clayton, while others are contained within Fulton County or the City of Atlanta. Almost all of the drainage basins in Fulton County drain to the Chattahoochee River which flows into the Gulf of Mexico.

Extent of Drainage Problem

Drainage problems within the unincorporated portions of Fulton County are handled by the Fulton County Public Works Department. Fulton County does not have a separate Drainage Department or Drainage Engineer as was the case in DeKalb County. One reason for this might be that much of Fulton County is still undeveloped and thus the County does not have the volume of drainage problems that DeKalb County has experienced.

It was estimated by the personnel of Fulton County's Public Works Department that approximately 70-80 residences in Fulton County experience "periodic" flooding problems. This periodic flooding problem was described as flooding the yards or basements of these residences once every year or two. The County has no records of any residence within the County being flooded above the basement or crawl space areas.

Fulton County does not have any accurate records or maps which show how many residences are actually located within the Intermediate Regional Flood Plain and thus cannot estimate how many residences might be flooded by a 100-year storm. Also, the Public Works Department has not kept records on how many drainage complaints they have received each year. The Department's personnel did state that most of the flooding problems that are reported to them are confined to the flooding of yards and the seepage of this water into the basements of adjacent residences.

In talking with the personnel of Fulton County the impression gained was that Fulton County experiences the same problems with drainage and sediment control that are evidenced in DeKalb County but the extent and severity are less. Much of Fulton County is classified by the Zoning Ordinance as rural land and to date has not been developed, but it is anticipated by the Fulton County Planning Department that development will occur within the near future. Thus, drainage might become a more important consideration within the County.

Fulton County Drainage Program

Fulton County's Drainage Program started with the 1967 Fulton County Subdivision Regulations which included Section 8.1.7. - Storm Drainage. This Section deals with storm drainage facilities within

subdivisions, extension of street drains on to subdivided land, designation of land unfit for development due to drainage problems, drainage problems as related to public health nuisances, requirements for water impoundment structures, and limitations of development within the 25-year flood plain.

In September, 1971, an official Flood Hazard Boundary Map was established and adopted by the County, consisting of a series of six maps prepared by the Planning Department of Fulton County. These maps depict the soil composition identified in the U.S. Soil Conservation Service Report, Soil Survey of Fulton County, Series 1949, Number 7; and data extracted from the U.S. Army Corps of Engineers Reports including the Flood Insurance Study, Fulton County Georgia (Unincorporated areas), June, 1971, which in conjunction established the flood hazard areas. These official Flood Hazard Boundary Maps identify the land which is within the Intermediate Regional (100-year) Flood Plain. The Corps of Engineers hydraulic studies covered approximately one-third of the major streams within the County while soils data were used to designate the flood plain associated with the other major streams.

To determine the exact nature and extent of the flood hazards for any individual property or small streams not covered by the Flood Hazard Boundary Maps, hydrological studies, engineering computations, flood records, and field surveys compiled and certified by a registered professional engineer may be required by the County before these areas can be developed.

On April 5, 1972, an amendment to the Fulton County Zoning Resolution Regarding Flood Protection was adopted by the County. This

amendment deals with uses within the 100-year flood plain (as determined by the County), permits for improvements within the 100-year flood plain areas, plans required, development standards, required hydraulic and hydrologic studies, erosion and sedimentation control, re-location or re-alignment of river and stream channels, and drainage easements.

A recent addition to this amendment entitled Control of Run-off and Sedimentation outlines in detail specific regulations designed to deal with the problems of erosion and sediment control. This addition also outlines the general procedures by which runoff from developed sites must be controlled. This addition was only in draft form at the time of this study and had not been formally adopted by the County. In addition there is an amendment to the Fulton County Zoning Resolution Concerning Tree Preservation which was adopted on July 15, 1968, and amended on December 3, 1970.

The Fulton County personnel interviewed during this study stated that the major objective of the Fulton County Drainage Ordinance is to protect the existing and future structures, within Fulton County, from experiencing any flooding problems. Stated another way, the major objective is to keep building out of the flood plain. In addition, the personnel from the Planning Department, who did most of the work in drafting the drainage ordinance, stated that the following objectives were also considered when the ordinance was written:

1. comply with the Federal Emergency Flood Insurance Program;
2. use the drainage easements created by the ordinance to create ribbon parks, open space, and buffer zones;

3. attempt to limit the use of channelization and encourage the use of natural drainage ways;
4. regulate the flow of water through the drainage system.

County Personnel Dealing with Drainage. The administration and implementation of the drainage program is shared by the Fulton County Planning Department and the Public Works Department. The Planning Department is primarily concerned with reviewing developments to be sure they are done in accordance with the latest zoning and subdivision regulations. The Public Works Department is primarily concerned with reviewing the grading and drainage plans to be sure they are in accordance with County standards.

The Public Works Department has six graduate engineers who spend at least part of their time working on drainage problems. The Planning Department has two planners who have been extensively involved in Fulton County's Drainage Program.

Fulton County has recently organized a technical review committee which is a multi-department committee (consisting of representatives from the Planning, Public Works, and Inspection Departments) which reviews proposed developments and tries to coordinate the efforts of all the departments to be sure the developments comply with all standards and regulations of the County.

Long-Range Goals of the Program. Fulton County has not established any long-range goals for their drainage program. At present, the County is working on broad goals for all the programs of the County, and it is anticipated by the personnel of the Planning Department that some goals for the drainage program will result from this work.

Current Objectives. As in the case of long range goals, the County has not specifically stated its current objectives for the drainage program. In discussing this with the personnel from the Planning and Public Works Department, they expressed the feeling that the first section of the 1972 Drainage Requirements (which is Section 9 of the 1972 Flood Protection Resolution) entitled Intent, could be viewed as a combination of goals and current objectives. Following is Fulton County's statement of the intent of their Resolution.

It is the intent of this resolution to delineate on an official map Flood Prone and Special Flood Hazard Areas in unincorporated Fulton County; to regulate the use and development of property located in such areas; to provide protection from flooding and inundation to persons and property; to prevent interference with the flow of any watercourse or into an impounding basin; and to prevent any appreciable expansion of flooding, siltation, erosion or inundation hazards. The delineation and regulation of areas affected by this section are intended to preserve and protect areas necessary for flood flows; permit appropriate land uses; protect persons, improvements and property from flood hazards associated with the development of areas subject to the movement and inundation of flood waters; and to preserve the flood plains from encroachment of any nature which would increase the need for flood protection, raise the flood level, reduce flood storage or impede the movement of flood waters; and to reduce the financial burdens imposed on the community by floods and their overflow. It is intended also to require the location, elevation, and construction of all public utilities and facilities, such as sewer, gas, electrical, and water systems and streets, in such a manner as to minimize or eliminate damage by flooding; to provide for adequate drainage to prevent the aggravation of flood hazards to adjacent communities; to provide that hereafter no platted lot shall be approved that does not contain a suitable building site having a first floor elevation above the level of the intermediate regional flood; to prohibit new construction accordingly; and to designate as non-conforming uses existing structures and development which do not meet the requirements of this section.

Current Level of Service. As part of their drainage program, Fulton County provides the following services:

1. Review plans for approval of development permits (taking into

account zoning and subdivision regulations), inspect work for compliance during construction, and make on-site inspection and review of "as built" drawings for final acceptance of work.

2. Provide emergency response to flooding situations, rendering such assistance as is necessary and possible to minimize hazards to life and property.
3. Maintain function of existing drainage structures and facilities specifically accepted for County maintenance; repair, modify or replace existing obsolete structures to extent of capability.

Methods and Studies Used in Drafting the Ordinance. The Fulton County Drainage Ordinance dated April 5, 1972, was drafted by the Planning Department and reviewed by the Public Works Department, County Attorney, and the Inspection Department. The Planning Department obtained most of their technical and engineering assistance from the U.S. Army Corps of Engineers and the Soil Conservation Service. There was very little interaction between the Planning Department and the Public Works Department during the drafting of this ordinance. At the time this ordinance was written, neither the Planning nor the Public Works Department has personnel with a background in drainage engineering or hydrology. The Public Works Department has recently hired an engineer with extensive experience in drainage work.

From a planning perspective there was a considerable amount of research done in preparation for the drafting of Fulton County's Drainage Ordinance. The Fulton County Planning Department contacted the Planning Departments of DeKalb County, Georgia; Atlanta, Georgia;

Baltimore County, Maryland; Fairfax County, Virginia; and San Jose, California to obtain information on their drainage programs and ordinances. In addition, the Planning Department used the facilities of the Georgia Tech Library to review the drainage ordinances of various other cities and counties throughout the United States and also reviewed current periodicals and law journals pertaining to urban drainage ordinances. The Planning Department also contacted and received information from the U.S. Department of Housing and Urban Development.

During this study, the Fulton County Planning Department did not contact the Public Works Department of these various cities and counties or solicit the advice or assistance of any engineers with a background in drainage and/or hydrology.

Many of Fulton County's personnel feel that there is a lack of communications between the planners and the engineers within the Fulton County government. It is apparent that the planners did most of the work in drafting the drainage ordinance while the Public Works Department was left with the role of reviewing the planners' work in its final stages of development.

Hydrologic Studies. The Fulton County Public Works Department has prepared a Manual on Drainage Design which is the basis for all the County's design work. The modified Burkli-Ziegler Equation for computing runoff is used as the basis for this manual and this equation is used for all hydrologic studies undertaken by the County. Neither this method nor the manual are required to be used by private developers in their design of drainage facilities but it has been the experience of the Public Works Department that most of the hydrologic studies that have been done in the

County have been based on the Modified Burkli-Ziegler Equation and the charts and nomographs contained in the County manual.

Problems and Results Obtained from Application of Ordinance.

Since Fulton County's Drainage Ordinance has only been in effect a short time, it is difficult to determine what effects it has had. The personnel within the Public Works Department state that they have had no major problems associated with the application or enforcement of the ordinance. They also feel that Fulton County, at the present time, does not have any major drainage problems and with enforcement of the existing drainage ordinance they will not have any in the near future.

Concluding Remarks

The major thrust of Fulton County's drainage program has been to keeping development out of the flood plain and, thereby, not lose any flood plain storage. In the past, the County has designed its drainage system to convey the storm runoff off the land quickly and then transport it through its drainage system and out of the County. It is just recently that the County has considered adopting an on-site storage requirement modeled after DeKalb's ordinance.

Almost all of the research and studies that were done in drafting Fulton's ordinance were done by planners in consultation with other planners with little input from engineers or public works personnel. This has resulted in the inclusion of some very general statements in the ordinance which have not been diligently enforced by the Public Works Department. It was reported by many of the Fulton County personnel that they felt the enforcement of the existing ordinance was very weak.

The ordinance has a major weakness in the area of sediment and

erosion control. Plans for sediment and erosion control are not mandatory in order for the developer to receive a development permit and thus few such plans are submitted. The Public Works Department reported that when plans for sediment and erosion control are submitted they are very general and most of the responsibility for the detailed plans and implementation of these plans is left to the developer. The Public Works Department also reported that they felt that erosion is one of the worst drainage problems in the County and that most of this was caused by the fact that developers do not stabilize the channels within their developments. The Public Works Department is left in a position of having to force the developer to rip-rap or in some way stabilize their channels after an erosion problem is encountered.

Fulton County does attempt to have some input into the structural adequacy of the dams and structures that are built within the flood plain. In the Fulton County 1967 Subdivision Regulations it states, "Any dam to be constructed within the County shall require the approval of the Public Works Department and the Health Department, and shall be constructed in accordance with standards and specifications as determined by them." The standards and specifications are those recommended by the Soil Conservation Service in building small dams.

Fulton County is experiencing the same problems with maintenance that are being encountered in DeKalb County. Because Fulton County is much less developed (percent of total area) than DeKalb County the public pressures are not great enough at this time to force them into accepting a greater role in maintenance. The County does not have a preventive maintenance program and most of the maintenance of the drainage system

is left to private landowners. The Public Works Department personnel stated that in the future they expect more maintenance problems associated with the drainage system.

One of the major things that is quite disturbing when studying Fulton County's Drainage Program is their lack of setting any goals or objectives for their program. The County has written and is revising their zoning and subdivision regulations concerning drainage, by utilizing the efforts of other counties and cities, without relating this information to what goals and objectives should be sought for Fulton County.

Clayton County

The Clayton County Planning Department has divided Clayton County into six major drainage basins. Two of these basins originate in Fulton and DeKalb Counties and drain into Clayton County. The rest of the basins have their headwaters within Clayton County. Of the six drainage basins, three drain to the east into Henry County while the rest drain to the south into Henry and Spalding Counties. Thus, Clayton County is both affected by and affects the drainage of several of the Atlanta Metropolitan Counties.

Clayton County Drainage Program

With the increasing flooding and drainage problems resulting from existing and anticipated developments in and around Clayton County, the County Public Works and Planning Departments are becoming more involved with measures to abate these problems. Among other things, the County is considering the use of on-site storage to control flood waters; has

several sections within its 1971 Subdivision Regulations dealing with drainage; drafted a proposed sediment control regulation; recently required drainage plans and studies for some new developments; and increased the technical ability of its Public Works Department to deal with the problems of drainage and sediment control.

County Personnel Dealing with Drainage. Clayton County's Public Works Department, with seven graduate engineers, has one of the largest engineering staff of any Atlanta Metropolitan County (several of these counties only have one or two graduate engineers). In addition, Clayton County has a Planning Department which has played an active role in the County's drainage program.

Formulation of Goals and Objectives. Like most of the counties and cities included in this study, Clayton County started its drainage program by enacting and proposing ordinances and regulations without first formulating any specific goals and/or objectives for the program. In interviewing two of the County Commissioners, they felt that it was logical that the formulation of goals and objectives should be one of the first steps in developing a drainage program. The County Planning Department has expressed an interest in working on county drainage goals and objectives and it is anticipated that this work will begin in the near future.

When the personnel within the Public Works Department were asked about goals and objectives they stated that their major goals were to prevent drainage problems that affect homeowners and save County maintenance money.

Current Level of Service. As part of their drainage program,

Clayton County provides the following services:

1. Review plans for approval of development permits (taking into account zoning and subdivision regulations), inspect work for compliance during construction, and make on-site inspection and review of "as built" drawings for final acceptance of work.
2. Provide emergency response to flooding situations, rendering such assistance as is necessary and possible to minimize hazards to life and property.
3. Maintain function of existing drainage structures and facilities specifically accepted for County maintenance; repair, modify or replace existing obsolete structures to extent of capability.
4. Provide technical assistance to the residents of the County to help alleviate drainage problems.

Methods Used in Drafting Clayton County's Regulations. The existing subdivision regulations, zoning resolution, and sediment control resolution in Clayton County, were drafted by the Planning Department. In drafting these regulations, the Planning Department used similar regulations in DeKalb County and several other counties as guides. The Clayton County Public Works Department did review and comment on the draft of these regulations, but were not involved in the drafting or formulation of them. In addition, during the drafting of these regulations input from engineers, either within or outside the County, was not solicited by those drafting the ordinances. A representative from the Soil Conservation Service did work closely with the Planning Department during the drafting of the sediment control regulation. Other

than this, these regulations were predominantly the product of the Planning Department.

Provisions of Clayton County's Regulations. The regulations now existing in Clayton County to control drainage are the Clayton County Land Subdivision Regulations and Zoning Resolution. The subdivision regulations limit development in areas where drainage problems exist, give specific standards for storm drainage design, limits development on land subject to flooding (as determined by the County Engineer), and give maintenance regulations.

The Clayton County Zoning Resolution has a section entitled Flood Plain Restrictions. This section gives information relative to determining flood plain areas, restrictions on building in these areas, limitations on cutting and filling operations in these areas, and flood plain uses allowed.

In addition to these Regulations, the County has adopted a Sediment Control Resolution. This resolution requires sediment control measures for all developments, list information to be submitted (plans, reports, etc.), design principles to be followed for effective sediment control, development standards, permits required, and maintenance provisions. For development standards, Clayton County uses the SCS publication, "Manual of Standards and Specifications for the Control of Soil Erosion and Sediments in Clayton County, Georgia."

Hydraulic and Hydrologic Studies. The Public Works Department only requires hydraulic and hydrologic studies when they feel there is a specific need for them. Thus, it is left up to the discretion of the County Engineer as to whether such studies are required for a given

development. The studies that have been completed used as a basis Talbot's Formula or the Rational Method. Most of these studies have been concerned with calculating the size of storm culverts and channels and not with calculating flood plain limits or retention storage.

Drainage Plans. On April 10, 1973, a memorandum was sent from Jack Wells (Chairman of the County Commissioners) to the Public Works Director and Chief Building Inspector stating the following:

Effective immediately, the Public Works Department will review drainage plans for all multi-family, commercial and industrial development before building permits are issued. This review will be similar to the subdivision plat review now in operation. Periodic inspections will also be made by the Public Works Department to see that approved drainage plans are complied with, and the final inspection by the Building Inspection Department will not be completed until the final drainage inspection is made by the Public Works Department. Signed letters or plans will be sent to the Chief Building Inspector by the Public Works Department indicating reviews and inspections have been made and approved.

Detention Storage Basins. The Clayton County personnel interviewed expressed the opinion that something would have to be done to control the increased runoff from developing areas within the County. At this time though, the County is taking a "wait and see" attitude concerning the use of detention storage as a means for controlling this runoff. The feeling was expressed that since detention storage was being extensively used in several other Atlanta Metropolitan Counties, Clayton County would wait and see how effective these installations proved to be before requiring the use of storage facilities in future developments.

Flood Plain Area. Clayton County uses the 100-year storm as the design storm for designating the flood plain areas. The U.S. Army Corps of Engineers have completed flood plain reports that cover about half

of the flood plain area within the County. The County uses the Soil Conservation Service Soil Maps for the remaining areas. Although the County doesn't have any accurate records concerning development within the flood plain, they estimate that there are 75-100 residential units, 5-10 small commercial units, and no industrial installations existing in flood plain areas.

Regulating Utilities in the Flood Plain. Clayton County does not have any regulations controlling the installation of utilities within flood plain areas. The County has only experienced minor problems with existing installations and does not foresee any major problems in this area.

Drainage Complaints. The Public Works Department receives about 10-15 drainage complaints per week. Most of these complaints concern flooding from small head water streams and not the major streams within the County.

Drainage and Erosion Problems. Following are some of the major drainage and erosion problems that were discussed with the County personnel.

1. There is a need for flood plain studies for the small rivers and creeks within the County.
2. It is difficult to get developers to control erosion and sedimentation problems without an ordinance.
3. Drainage is neglected too often during the development of projects.
4. Drainage has to work as a system and the County should have more authority within the areas outside of the County

right-of-way.

5. The Public Works Department feels that the existing ordinances are inadequate and not specific enough (this comment was prior to the adoption of the sediment control resolution). There is a need for more stringent technical specifications.

Concluding Remarks

Clayton County is just beginning to formulate their drainage program. The Public Works Department has, within the last three years, hired several qualified personnel so they can put forth an effective drainage program, from a technical and administrative perspective.

At the present time, the County officials are trying to hold back the pressures from the local citizens to enact an immediate and quickly put together drainage program. The County officials realize that they will be dealing with the results of whatever program they enact for many years. Because of this, they have taken the position of slowly evolving their program and benefiting from the experiences (both good and bad) of their neighboring metropolitan counties.

APPENDIX A REFERENCES

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3. Grablowsky, Bernie J., Manual on Drainage Design, Prepared for Fulton County Public Works Department, August 28, 1967.
4. Subdivision Regulations, Fulton County, 1967.
5. Soil Sedimentation Control, Fulton County, Georgia, Prepared by Fulton County Department of Planning, April 1972.
6. Flood Protection for Fulton County, Fulton County Planning Department, October 1971.
7. Rules and Regulations Governing Private Development of Sanitary or Storm Sewers in the Atlanta Metropolitan Sewer System, Department of Public Works, Water Pollution Control Division, City of Atlanta, Georgia, February 1967.
8. Wagnon, Lloyd, Drainage Engineer, Status Report Storm Drainage, Roads and Bridges Department, DeKalb County, Georgia, January 17, 1973.
9. Drainage Improvements Program, Prepared by the Planning and Roads and Drainage Departments, DeKalb County, Georgia, April 1973.
10. Wagnon, Lloyd, Drainage Engineer, DeKalb County's Drainage Ordinance Report to DeKalb Development Workshop, July 21-22, 1971.
11. Land Subdivision Regulations and Standards and Specifications of County Engineer, Prepared by the Clayton County Planning Department, Clayton County, Georgia, December 16, 1965.
12. Numerous memos, letters, reports, regulations, and ordinances pertaining to drainage from the City of Atlanta, DeKalb, Fulton and Clayton Counties.
13. The following persons were interviewed or their opinions were obtained concerning certain portions of the material contained in these case studies:

Atlanta Metropolitan Area

Mrs. Mary Anne Whatley	Executive Vice-President Home Builders Association of Metropolitan Atlanta
George Eichler	Head Planner Environmental Services Division Atlanta Regional Commission
William Kroeck	Environmental Services Division Atlanta Regional Commission
David Hopkins	Chief Environmental Impact Statements Branch Environmental Protection Agency
Sam Cowan	Corps of Engineers Chief Flood Plain Management Branch

Local Consulting Engineers

James M. Patterson	Patterson & Dewar Engineers
Conny Bird	Watts & Browning Engineers
Rollie Bailey	Cheatham Engineers
Robert Cook	Evan L. Marbut and Associates
Don Heild	D. E. Hill Engineers
Joel Granade	Joel J. Granade Construction Engineers
Jose Anez	Thomas M. Lowe Jr. & Associates
Billy Turner	Jordan, Jones & Goulding
Herb Miller	Jordan, Jones & Goulding
Robert Holbrook	Black, Crow, & Eidsness Engineers
Robert Morriss	Black, Crow, & Eidsness Engineers
R. D. G. Pyne	Black, Crow, & Eidsness Engineers
Steve Bull	Legal Staff Black, Crow, & Eidsness Engineers

Also numerous discussions
with local consulting engi-
neers and surveyors dealing

with drainage designs in
Cobb County.

City of Atlanta

Public Works Department

Pelham C. Williams	Director
Fred Artis	Special Projects Officer
Nolan Johnson, Jr.	Civil Engineer
Raymond Adair	Private Development Co- ordinator
Walter Brown	Assistant Private Develop- ment Coordinator
R. C. Pace	Superintendent Sewer Mainte- nance & Construction
James Hunter	Chief Consumer Services
Joe McCannon	Assistant Chief Zoning Administrator

Planning Department

Wilson Smith	Planner
------------------------	---------

Commissioners

Jack Sommers	Commissioner
John Calhoun	Commissioner
Hugh Pierce	Commissioner
James Howard	Commissioner
Charles Helms	Commissioner

DeKalb County

Roads and Drainage Department

Levi Brown	Director
Lloyd Wagon	Drainage Engineer

Planning Department

Ed Anderson	Assistant Director
Francis Maloney	Planner

Commissioners

Horris Ward	Commissioner
Robert Morris	Commissioner
William Collidge, Jr.	Commissioner
Hoke Smith	Commissioner

Fulton County

Public Works Department

Turner McDonald Director
 Howard Frandsen Assistant Director and Chief
 Engineer
 Howard Gunn Chief Inspector
 Jody Hunnicutt Civil Engineer
 James Rigby Civil Engineer

Planning Department

Larry Fontz Director
 Bill Hunter Planner
 Bill Huff Planner

Commissioner

Goodwyn Cates Commissioner

Clayton County

Public Works Department

Steve Richardson Director
 Richard Ridling Deputy Director
 Vanchat Kanchanakomtorn County Engineer
 John Carr Engineer
 Bhushan Sawhney Engineer

Planning Department

Thomas Hawkins Director
 Rex Curry Planner

Commissioner

Jack Wells Commissioner

Administrative Assistant

John King Administrative Assistant

APPENDIX B

FAIRFAX COUNTY, VIRGINIA

Fairfax County's geography is such that almost all of the lands constituting the drainage basins of the streams within the County lie within the County's boundaries. The County Development Department has divided the County into 30 major watersheds (Figure B-1). Twenty-five of the major watersheds lie wholly within the County while the other four drain into or from Loudoun County to the northwest of Fairfax County. Eventually all of the water from Fairfax County drains into the Potomac River and on to the Atlantic Ocean. The topography within Fairfax County is characterized by gently rolling countryside.

Extent of Drainage Problem

Fairfax County does not have any accurate records or maps which show how much development is now existing within the 100-year flood plain. Several of the County personnel interviewed stated that there was a significant amount of existing development within the flood plain. This was borne out when hurricane Agnes passed through the County in June of 1972 resulting in an estimated 25 million dollars worth of damages, far more than in any other county in the state (1). In many areas of the County the real tragedies occurred along the small tributaries. Every creek and stream overflowed its banks damaging adjacent land and property.

Fairfax County has also experienced major problems in the area of

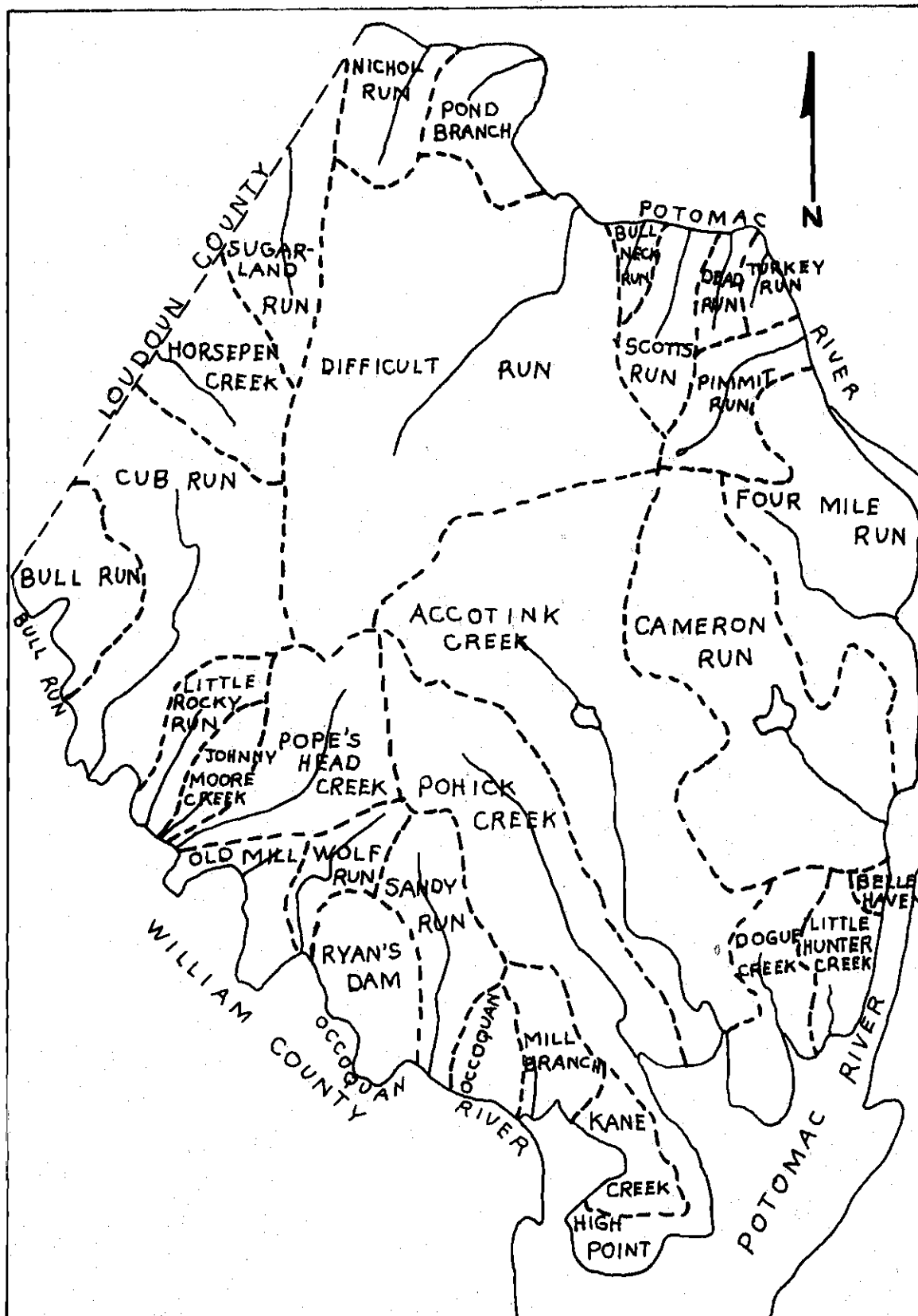


Figure B-1. Fairfax County, Virginia - Major Drainage Basins

erosion and siltation. Fairfax is one of America's most rapidly growing counties, population-wise. About 30 percent of its area is already built up, and 35 percent is in the process of development (2). Records to show the extent or severity of these problems were not available but a complete discussion of Fairfax's erosion and sedimentation control program is included later in this study.

Drainage problems within Fairfax County are administratively handled quite differently than in the other areas studied. Thus, a brief discussion of the administrative organization existing in Fairfax County is necessary. Drainage problems are handled either by the Department of County Development or the Department of Public Works.

Department of County Development

The Department of County Development was established in 1969 to place the regulation of land use under a single organization. This Department controls land development in accordance with Board of Supervisors' policies and adopted ordinances, from zoning of land through the processing of plats, plans for subdivisions, commercial, multi-family and industrial development, to the issuance of residential and non-residential use permits.

The County Development Department is divided into five major divisions (administrative services, mapping, inspection, zoning administration, and design review) of which the Division of Design Review is of most interest to this study. County ordinances establish standards for development of property, including such matters as grading, lot layout, street patterns, location of structures, street construction design,

storm and sanitary sewer design, and similar features.

The Division of Design Review enforces these ordinances by reviewing and approving plans for new subdivisions, commercial, and industrial development within the County. This division also administers the assignment of street names and addresses, reviews building permits to ensure that the proposed grading will preclude drainage problems and to ensure that no houses are constructed within a flood plain, and issues utility permits for work in dedicated rights-of-way. This division also reviews plans for erosion and siltation control.

When fully staffed the Department of County Development employs 311 personnel. Within the Division of Design Review are employed 20 Engineers (10 of these are registered professional engineers and 6 have done some graduate work in engineering).

Thus, the Department of County Development and more specifically the Division of Design Review deals with most of the subjects that are of concern in this study.

Department of Public Works

The County Department of Public Works is responsible for sanitary sewerage facilities, all County facility design and construction (except schools facilities), land acquisition for the County Government, storm drainage maintenance, collection and disposal of solid waste, leaf collection, planning and development of street lighting, and school sidewalk projects.

The Department of Public Works, whose primary functions are in the area of maintenance, receives and processes approximately 100 complaints per month. Although this is a significant number it represents

only about half as many complaints as were reported by DeKalb County, Georgia.

Fairfax County Flood Control Program

Until 1972, the philosophy of the County concerning its flood control program remained relatively unchanged from when the County first drafted its original drainage ordinance in 1963. In 1972 the County's long standing policy of getting the water off the land and into the drainage system and then out of the watershed as fast as possible changed to a concept of retaining the flood waters in order to:

1. recharge this storm water into the ground water system,
2. reduce the peak flood flows and the size of the required drainage system downstream.

Thus the present County ordinance contains essentially the same general policies as the 1963 ordinance except for this recent interest in storm water retention.

Goals and Objectives of the Flood Control Program

The County has not specifically stated any long or short term goals and objectives for its flood control program. A major drainage study now in progress does have as one of its objectives the formulation of goals and objectives for Fairfax County's drainage and flood control program. From interviews with County personnel the following items represent the general opinion of what these goals and objectives might be:

1. Control storm water and keep it out of existing and proposed development.

2. Minimize the possible damages from major flooding.
3. Provide for the safety of existing and proposed developments.
4. Continue development of the area without creating environmental problems.
5. Develop a comprehensive drainage plan for the County to handle storm runoff safely and efficiently.
6. Regulate development so as to prevent an increase in runoff rate from the development site.

Evolution of the Fairfax County Drainage Ordinance

The manual that contains the County Drainage Ordinance is entitled, "Policies and Guidelines for the Preparation of Subdivision Plans and Site Development Plans". The Board of County Supervisors in 1958 directed the Department of Public Works to prepare this manual. The guidelines and other information contained in this publication include the basic information that the Department of Public Works then had available and also an updated version of the check lists for drainage design developed by the Division of Streets, Drainage and Subdivision Design, over a period of years. This manual has been reviewed by Professional Engineers practicing in the County, and their recommendations were incorporated when possible.

The Public Works Department kept this manual updated from 1958 to 1969. At this time there was a reorganization of the County government and the Department of County Development was assigned this function. The Engineers from both the Public Works Department and the Department of County Development have had considerable input into the existing ordinance. Although no formal studies or research were done during the

drafting or updating of this ordinance, the County has made it a policy to keep in close touch with other political entities throughout the country in order to benefit from their efforts and experiences in the area of urban drainage.

Fairfax County's Office of Comprehensive Planning has also been involved in the overall drainage program but in an advisory capacity. This office has been very active in land use planning and projections which are essential to any drainage program.

In addition, the Board of County Supervisors also established a continuing review committee to evaluate the guidelines contained within this manual. This committee consisted of one representative from each of the following organizations:

1. Department of Public Works, Fairfax County,
2. Northern Virginia Chapter of the National Society of Professional Engineers,
3. Northern Virginia Builders Association,
4. Mt. Vernon Chapter of the Virginia Association of Surveyors,
5. Home Builders Association of Suburban Virginia,
6. Fairfax County Federation of Civic Associations.

In 1972 Fairfax County adopted a new Public Facilities Manual which contains a section on Drainage. This section gives detailed criteria on drainage design, studies required, flood plain calculation, and miscellaneous development standards. In addition to this manual, the County has also formally adopted several policies that are directly related to this study on urban drainage ordinances. Following is a description and discussion of these policies.

Policy on What May be Done in Flood Plains. It is recognized that some improvements must be made within flood plains, streams and/or drainageways in such a manner that the increased runoff from changes or improvements within the watershed may be accommodated without unacceptably elevating flood plain or stream levels particularly within improved or developed areas. This may take the form of stream bed clearing, removal of obstructions, reduction or constrictions, stabilization of stream bottoms and/or banks or areas to eliminate or reduce erosion, widening deepening or realigning of streams to provide the necessary hydraulic characteristics to accommodate the anticipated stormwater flow without damaging adjacent properties. These improvements should include the removal of silt and debris which may clog or damage downstream drainage structures or property, the filling or drainage of ponding areas and stagnant pools which are potential vermin shelters and mosquito breeding areas. Recognizing the right of a land owner to the full lawful use of his land and the County's responsibility for the protection of the health, safety and welfare of its citizens, back water areas may be filled when they are not required as safety valves or temporary retention reservoir to control downstream runoff intensity so long as the necessary drainageway is preserved and filled or excavated areas are adequately stabilized against erosion.

You can develop and build within the flood plain if the floor level of all structures is at least 18" above the flood level. In other words you can construct the buildings on stilts or piers and these can be placed within the flood plain. The ordinance also allows filling within the flood plain as long as the hydraulic characteristics of the flood plain are not changed. Equal amounts of storage must be provided to compensate for the storage that is lost due to the filling.

There are no specific regulations within the ordinance dealing with the location of pipes and utility lines crossing the flood plain. Although these installations can sometimes obstruct flows, the County personnel reported that they have not experienced any problems with these installations.

Policy on Retention of Storm Waters. It is the intent of this policy to encourage the use of various methods for the on-site retention of storm waters in the interest of minimizing the

adverse effects of increased storm water runoff, (resulting from development of land within the County), on downstream drainage ways such as stream valley parks and natural flood plains. Some methods are discussed in the following paragraphs but new approaches to accomplish this are to be encouraged.

Temporary on-site retention of storm water is desirable in many cases to alleviate existing downstream drainage problems when the system is clearly inadequate and its expansion is either financially prohibitive or aesthetically unacceptable.

The release rate from any temporary ponding area should approximate that of the area prior to the proposed development for the design storm, but adequate alternate drainage must be provided to accommodate major storm flows.

The roof tops of buildings may be used for this purpose but care should be taken to design the buildings to accommodate the additional live loading involved.

Retention pools or basins in parks (subject to the approval of the Park Authority), playing fields, parking lots or storage areas can be constructed to reduce peak runoffs downstream by providing temporary on-site storage. Care must be taken to see that such temporary ponds do not become nuisances or health hazards. The maintenance responsibility will be clearly stated on the plans.

Previous material may be used where practicable as an alternative to parking area paving, which would allow the storm water to be more readily absorbed by the ground rather than adding to additional runoff. This practice is not applicable to areas where a high water table exists or where subsoil conditions are not suitable.

This policy was adopted by the Board of County Supervisors on September 18, 1972 and has been interpreted by the County so that storm water retention-detention facilities must be evaluated for all storm drainage plans proposed for development in the County. This policy supersedes the 1971 County policy of requiring the installation of temporary storm water detention ponds only for development in areas where downstream storm drainage systems were not adequate to receive the increased runoff being generated by the upstream development, and definite planning was not available for improvement of the inadequate downstream drainage system.

The County has not established any rigid standards to be used in designing the required detention basins. Each application is looked at separately and the best possible solution is determined for that application.

If a developer decides not to use retention storage then he must show that the increased runoff from his development will not overtax the existing drainage system downstream or that it is impossible to "reasonably" incorporate retention storage within or downstream from his development and that another solution is possible.

The first storm water retention facility constructed in Fairfax County was Lake Anne located in Reston, Virginia. Lake Anne is designed to receive a peak 100-year inflow of 3,350 cfs and discharge it at a maximum rate of 600 cfs. This controlled discharge from Lake Anne, which flows into Lake Fairfax, was given credit for saving Lake Fairfax from complete destruction during the Hurricane Agnes storm in June, 1972, which topped the Lake Fairfax dam, destroyed the dam's spillway and about 200 feet of the dam's downstream slope. Reston has installed a second retention facility, the Upper Snakeden Dam, and has approved plans to enlarge the Lower Snakeden Dam and convert it to a better retention facility. It is anticipated by the County that these three dams will create fine recreational facilities, high priced lake-front lots, as well as excellent storm water retention facilities.

In compliance with the 1971 Fairfax County policy which required the installation of temporary storm water detention ponds for development in areas where downstream storm drainage systems were not adequate to receive any increased runoff, three detention ponds were constructed at

Tyson's K-Mart, Oakton Shopping Center, and Sunset Village. These ponds were also used as silt control structures. The ponds were all in operation during Hurricane Agnes and provided adequate storage capacity for this storm. It is anticipated by the County that these ponds will continue to provide detention storage until downstream drainage systems are improved.

In addition to these privately constructed storage facilities, Fairfax County adopted the Pohick Watershed Plan in the late 1960's and in cooperation with the Soil Conservation Service and landowners, are proceeding with the construction of 8 retention dams in this watershed. To date, Lake Braddock, Dam No. 7, has been completed, Dam No. 8 is under construction and construction bids are being taken for Dam No. 4.

Policy on Off-Site Drainage Improvements. In the interest of the health, safety and welfare of all, when the appropriate land use has been determined for any area to be developed, the County reserves the right to require the developer to show that off-site downstream drainage can be accommodated (considering the planned development of the contributing watershed) without damage to existing facilities or properties before such development is approved for construction.

Where a developer chooses to contribute his proportionate share towards the correction of off-site outfall deficiencies, the County may accept such contributions towards their correction, and accepts the responsibility to its citizens for the initiation and prosecution of projects for the alleviation and/or correction of storm drainage deficiencies insofar as funds can be made available for their accomplishment. The proportionate cost of such downstream improvements is represented by the ratio that the runoff from the property, when developed, bears to the total runoff-off expected within the watershed or affected portion thereof.

Where the developer chooses to either construct or provide the funds for the construction of more than his proportionate share of the downstream off-site drainage improvements so that he may proceed with the improvement of his land without damaging the properties of others, the County will endeavor to collect, on a pro-rate basis, any excess funds expended beyond his proportionate share of the cost of such improvements from other properties within the watershed served by such drainage improvements when

such properties are developed within a period of ten years from the date that the drainage improvements are financed or constructed and to turn these funds without interest over to the initial developer or his assigns.

This policy has been in effect since 1963 and the County reports no problems with enforcing it or getting the necessary cooperation from the developers involved.

Policy on Proportionate Cost - Off-Site Drainage Improvements. Development within a watershed involving a change of land use therein, is normally associated with an increase in impervious areas resulting in a greater quantity as well as a more rapid and frequent concentration of stormwater runoff. The construction of storm drainage improvements will be required along waterways as shed development progresses to alleviate flood damage and arrest deterioration of existing drainageways. The extent and character of such improvements shall be designed to provide for the adequate correction of deficiencies, and will extend downstream to a point where damages to existing properties ascribable to the additional runoff will be minimized.

For the purposes of prudently providing for the orderly development of drainagesheds and establishing a usable facility along waterways that may be reasonably maintained, the financing of required improvements will be pro-rated over the contributing area.

The proportionate cost of off-site drainage improvements attributable to existing and proposed developments will be based upon the project cost of those downstream facilities that function to convey the stormwater runoff originating within the contributing shed limits of the development, and in the proportion that such runoff bears to the total being conveyed.

To facilitate the computations for pro-rating drainage costs, impervious area may be substituted for runoff quantities.

The cost of off-site downstream drainage improvements attributable to an acre of impervious area shall be based upon a distribution of the total downstream improvement cost over the entire impervious area within the contributing shed.

The impervious area will be determined from the most current and expected land use plans. The cost distribution shall be derived by dividing the contributing impervious area into the improvement cost of each downstream reach and preparing a summation of the same.

To fully understand the meaning of this policy some further discussion of pro-rata costs is needed. It is the policy of the County

that the Board of Supervisors initiates all plans where pro-rata can be used. In other words the County has designated certain areas of the County where pro-rata cost sharing can be used and other areas have not been so designated at this time. It is anticipated that the entire County will be included in the pro-rata system in the near future. After an area has been designated by the Board, a private engineering consultant firm is retained to design the engineering works needed to handle the anticipated surface water that will be generated from the planned ultimate development of the area.

This engineering consultant firm determines the following for each watershed involved:

1. The extent of improvements needed within each watershed.
2. The costs associated with these improvements.
3. The cost/impervious area - Each watershed is divided into sections perpendicular to the direction of the natural channel. The distance that each section runs up and downstream is not a constant but varies in an attempt to divide the watershed into sections where the flows within each section will not vary greatly. (e.g., if a major tributary enters the main stream this would be a probable point where a new section would begin). After the sections have been designated then a cost/impervious area for each section is determined. Since the County feels that upstream developments use more of the drainage system to convey their runoff to the nearest outfall than downstream development, they are assessed at a higher rate (cost/impervious area) than the

downstream development. Thus the development furthest upstream pays the highest assessment while the development adjacent to an outfall pays the lowest. The selection of a cost/impervious area for each section is somewhat subjective and judgment plays a major role.

In order to obtain some uniformity in the calculations of impervious areas for different developments the County has set up some standards. These standards state the amount of impervious area as a percentage depending on the type of development. Following are some of the standards used by the County:

<u>Residential</u>	<u>% Impervious</u>
8400 sq. ft.	37
10500 sq. ft. R-10	36
12500 sq. ft. R-12.5	28
17000 sq. ft. R-17	25
21000 sq. ft. RE-1	20 (1/2 acre or more)
Schools	50
Business	90 (varies)
Townhouses	75
Apartments	75
Cemetarys	20
Parks	15

Thus to obtain the pro-rata cost for a particular development the following formula would be used:

$$\text{Total area (in acres)} \times \% \text{ Impervious} \times \text{Cost/Impervious Area}$$

Hydrologic Studies

The rational formula ($Q=CIA$) is recommended by the County for determining quantities of runoff for areas up to 200 acres. The Anderson formula ($Q=230KRA^xT^{-0.48}$) is recommended for determining quantities of

runoff for areas greater than 200 acres. The 200 acres is somewhat of an arbitrary cutoff point but it represents the lower limit recommended by Anderson when using the Anderson formula.

The County feels that the rational method has given satisfactory results since they have not experienced any major failures of the structures designed by this method. There has also been very little maintenance and related problems caused by these structures.

To designate their flood plain the County previously used a 10-year design storm with 2 feet of freeboard, but they now use a 100-year design storm with no free board. In several areas the County found that the area inundated by the 100-year storm would be less than that estimated by using the 10-year storm with 2 feet of freeboard. The U.S.G.S. did most of the design work in determining the 100-year flood plain for the major streams (drainage areas of 1 sq. mi. and larger). The U.S.G.S. based their design on the Anderson formula. When a developer wants to develop an area that is not covered by these studies then he must calculate and determine the location for the 100-year flood contour elevation and submit this calculations to the County for approval.

Fairfax County does not recommend any particular method for designing detention storage facilities. The County does feel that some hydrograph analysis is necessary for an adequate design of such a structure. The Soil Conservation Service's hydrograph analysis method has been used in designing several of the storage facilities now in use. The County emphasizes the fact that this concept of retention storage is new to them and they are open to new designs and procedures. At this point in the County's development of procedures regarding retention storage they

are approaching each application as an individual case and using the best design to fit that situation.

Erosion and Sediment Control Program

The County's erosion and sediment control program got its start in 1962 when the Soil Conservation Service assigned a soil scientist to the County for the expressed intention of dealing with some of the problems of erosion and sedimentation from construction areas. Before this, the SCS was used only to assist farmers with their conservation problems. In 1966 the County drafted a very general erosion control ordinance. Since that time Fairfax County has been very active in the area of erosion and sediment control and their present ordinance and Erosion-Siltation Control Handbook have been used by many other cities and counties. The County realizes that new techniques and methods for erosion and sediment control are constantly being researched and developed and that any program must remain flexible in order to incorporate these advances. This attitude can best be seen by reading the "note" at the beginning of their Erosion-Siltation Control Handbook:

This handbook retains its "draft" label because of the amount of experimental work being done in urban erosion and siltation control and the continued difficulty in setting specific quality standards.

Erosion and Siltation Control Ordinance

Fairfax County's current Erosion and Siltation Control Ordinance includes the following:

1. requirements stating when erosion and sediment controls are required,
2. plans and specifications required,

3. bonding requirements,
4. policies and guidelines pertaining to erosion and sediment control,
5. a five stage process for submitting development plans including submittal and review of preliminary and final plans,
6. detailed list of typical measures to be used for erosion and sediment control.

General Comments Concerning Erosion and Sediment Control Program

Fairfax County has developed a keen interest in the area of erosion and sediment control which can be seen in the magnitude and scope of their ordinance and program. The neighboring counties in Maryland also have extensive programs in this area, and Fairfax County officials have availed themselves of much of the experience that the Maryland counties have had.

Fairfax County uses several methods to control erosion and sedimentation. Sediment basins, dikes, straw, mulch, and seeding are the methods usually used and the ones that have produced the best results. The County feels that the best approach to the problem is the combined use of seeding, mulched dikes, and some storage facilities (used for both storing storm water and also as a sediment basin). The County normally requires that the developer seed and mulch all exposed areas 60-90 days after it is cleared but this restriction has not been strictly enforced. In setting time limits within which cleared areas must be seeded and/or mulched, several of the County personnel expressed the opinion that it might be better to vary these limits according to the soils, topography, time of year, etc., but the County doesn't at this

time. Temporary vegetation and mulching is required if the site is cleared and it is expected to lay idle for some period of time before development. The County uses a 10-year design storm for all sediment basins.

The County has not studied the effectiveness of the measures they use except for inspections of the site during and after development and visual effects downstream. No research has been done to determine how much sediment is trapped and how much passes through to downstream areas. The County does have a program for periodic sampling of the major lakes and streams but this is used to determine general trends in sediment production and not to test the effectiveness of any specific methods.

County personnel feel that the major problem with their erosion and sediment control program is the inspection. Most of the inspection is done as a result of a complaints, "after the fact" when little can be done. In addition, utility inspectors are used as inspectors for erosion and sediment control and usually lack the experience necessary for effective inspection within this area. Twice a year the County Development Department does give an erosion and sediment control refresher course to its inspectors in an effort to correct this situation and provide interaction between the Plan Review Section and the Inspection Department.

Comprehensive Plan for Flood Control and Drainage

In May, 1972, the Fairfax County Board of Supervisors retained Parsons, Brinckerhoff, Quade and Douglas, Inc., as its flood control and storm drainage consultant, to prepare a Comprehensive Plan for Flood Control and Drainage for the watersheds of the County. The development

of this Master Plan will be based on the overall philosophy that storm water runoff is a resource to be used in as many ways as possible within the County before passing it to the downstream channels. Dynamic flood and drainage models will be developed for each drainage basin. Those land areas of the County that are committed to be used as floodways will be planned for every multiple land use that may be identified to benefit the County, such as linear green belts or fenways, developed recreation areas, open park areas, and siltation control facilities.

The Consultant will develop a detailed work program for the Master Plan for Flood Control and Drainage for Fairfax County. Within the process, specific criteria will be developed with the County to aid in setting objectives. Available data will be assembled and evaluated for its use in the study. Liaison with concerned agencies will be established by the Consultant.

Specifically, the Consultant is to provide a general overview of County drainage work and a review of drainage plans submitted in the name of various developments, to determine general adequacy of these plans and their compatibility with County drainage objectives. Existing drainage programs are also to be reviewed to determine their effect upon and compatibility with County drainage objectives. The Consultant is to develop, through special studies, solutions to siltation and debris control problems. Variations on the general concept of detention basins will also be explored. New drainage program concepts will be developed and analyzed. The concept of storm runoff as a resource out of place will be pursued in finding productive and useful purposes for the storm water. Other special studies will be performed as the need for them is

defined.

The Consultant will consider the need for a project/public awareness program that will have the purpose of including the ideas and concerns of the citizenry of Fairfax County in the development of planning concepts. The awareness of the general public of the problems of flood control, siltation, debris, detention basin operation, flood waters diversion and use, etc., may also be made the concern of the Consultant.

For each drainage basin within the County, as defined by the County, a basin drainage plan is to be developed. The plan will include a dynamic flood waters and drainage model of the basin and a set of flood control improvement projects which may become active as growth and changes in land use take place. Specified water surface and peak flow discharge limits for the design storm will provide the basic control on runoff changes with changes in land use. The County will establish the priorities in which the various drainage basins will be studied.

Subsequently, the Consultant will prepare the County Master Plan for Flood Control and Drainage which will integrate and incorporate the various individual basin plans into a single comprehensive, county-wide plan. Recommendations for changes in the County Code to implement the results of the Master Plan will be prepared.

The Consultant will prepare Environmental Assessments as required to support the on going program of flood control and drainage planning and to assure that environmental concerns are properly included in the planning program.

In the development of the County Comprehensive Master Plan for Flood Control and Drainage, the Consultant will give major emphasis to

the following:

- A. The use of mathematical/computer modeling methods for watershed evaluation and management.
- B. A review of the County's methodology of calculating storm water runoff, both locally and on a basin basis.
- C. The concept of retaining initial storm water flows on-site to the maximum extent possible.
- D. The evaluation of ground water hydrology within the County and ways in which the ground water may be added to through accelerated storm water infiltration.

As a general consultant to the County, the Consultant will serve in implementing the design and construction of those physical facilities that are identified to be required for flood control and drainage. Facility design and technical inspection of construction by others will be overseen and guided by the Consultant, as agent for the County. Selection of Section Engineers to prepare specific designs will be made by the County. Other assignments relating to flood control and drainage within the County of Fairfax will be performed by the Consultant as directed by the County.

Fairfax County feels that this broad scope of activities for the County's Drainage Consultant will result in Fairfax County having the most comprehensive, environmentally sensitive, economic plan for flood control and drainage of any area in the country.

In this study, the consultant will consider anticipated development in the years 1980, 1990, and 2000 and propose drainage facilities for the entire County under these development conditions. A pro-rata

system of cost sharing will then be set up for the entire County to cover the cost of these facilities. Each drainage system and sub-section will have its own costs depending on the drainage facilities needed.

The consultant is using the MIT Catchment Model to simulate the hydrology within the different watersheds. This model can be used to detect a change in land use of 50 acres or more. The model will be used to look at both changes in peak flows and volumes under varying conditions of land use. Thus the County will be able to use this model to test different alternatives to its development pattern. In addition, with the use of pro-rata in combination with the model results the developer will then be paying for the actual changes in the peak flows and volumes of flows that result directly from this development.

Problems Encountered in the Application of Fairfax County's Drainage and Erosion Program

Inspection seems to be the major problem with the County's program. The County personnel report that both the quantity and quality of inspectors need to be improved. They report that many projects are not constructed according to the plans because of the lack of adequate inspection. Erosion and sediment control measures are not maintained during the entire construction process and thus at times, they become ineffective or inoperative. In addition, many of the County regulations concerning erosion and sediment control (e.g., mulching, seeding, use of other sediment control methods) are not strictly enforced.

This problem of poor inspection is complicated by the fact that the engineers and designers within the Design Review Section do not have the time to do much inspection of the projects. Thus there exists a gap

between the review of the plans, proposed procedures and methods, and the actual implementation in the field.

Several interviews were conducted with local engineering consultants to get their views of the County's program. Generally the consultants were in agreement that Fairfax County was a "leader" in storm drainage and erosion control and that their overall program was good. The consultants felt the County program allowed the flexibility that the engineers needed to design the best drainage system for each development, and that the ordinances were not so restrictive as to usurp judgment from the engineer.

The consultants felt very strongly that the engineer should be able to express his opinion whether or not on-site storage should be used to solve a given drainage program. They felt a blanket rule of on-site storage for every development is not a good solution to drainage problems, because some sites may not have suitable areas for storage facilities and another solution might be much better from an engineering, economic or aesthetic point of view.

Although the consultants agreed there were no major changes they would like to see in the County's program there were several areas in which they expressed some concern:

1. More hydrologic research should be done within the County.
2. Research should be done with regard to maintenance and economics of different drainage structures.
3. Study and research is needed in the area of on-site storage.
4. Study the possible problems with using roof top storage
(specifically with regard to freezing and possible buildup

problems).

The consultants agreed that inspection was the major problem with the County's program. Some possible solutions to this problem that they brought out were:

1. Hire a consulting firm to do the inspection.
2. Better train the inspectors, two year technical graduates might make good inspectors.
3. Have the professional engineer that works on the design also be responsible for some of the inspection.

Concluding Remarks

For years Fairfax County has shown much concern in the area of erosion and sediment control. Along with their neighboring Maryland Counties they were one of the first areas in the country with many facets of their program. At the same time the philosophy that permeated their drainage program was one of conveying the water off the site and into the drainage system as fast as possible. Today this philosophy is changing to one of trying to keep the runoff on the site and slowly discharging it into the drainage system. Thus through a process of many years of evolution the County now has extensive ordinances covering drainage and erosion control in conjunction with several handbooks and other literature.

One of the major differences between the Fairfax County program and that found in the Atlanta Metropolitan Area is maintenance. Fairfax County maintains the entire drainage system except for retention ponds constructed on industrial or commercial land, which are maintained by the property owners. If these ponds are not maintained the County will go in and maintain them and put a lien on the property to cover the costs

incurred. Retention ponds constructed in residential areas are maintained by the County. The County also does not maintain the drainage facilities that are within the State's highway system right-of-way, since these are maintained by the State.

The County does not have jurisdiction within the incorporated areas of the Cities of Fairfax, Vienna, Falls Church, Clifton, and Herden but it does maintain the drainage system within these areas.

Fairfax County's drainage and erosion program has many strong points which were brought out in the previous discussions. Most of the problems that have been encountered resulted from a lack of enforcing the provisions of the program rather than a weakness in the program itself. As in several of the other areas studied, the one major weakness of the overall program is the lack of setting and clearly defining the goals and/or objectives. This problem may stem from the lack of input that planners have had in the County's program. The planners input has been confined to designing the Master Land Use Plan for the County, which is then used as the ultimate development for the hydraulic and hydrologic studies.

APPENDIX B. REFERENCES

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10. Fairfax County Virginia, Erosion-Siltation Control Handbook, April 1973.
11. Fairfax County Virginia, "Drainage", Section 2 of the Fairfax County Public Facilities Manual, October 1972.
12. Numerous Fairfax County memos, letters, reports, regulations, and ordinances pertaining to drainage.
13. The following persons were interviewed or their opinions were obtained concerning certain portions of the material contained in this case study.

Personnel Interviewed in Fairfax County

County Development Department

D. E. Stricknouser	Deputy Director
William J. Bromley	Assistant to the Director
Payne Johnson	Chief-Plan Review Board
William W. Henry	Assistant Branch Chief - Plan Review Branch
William W. Smith, Jr.	Assistant Branch Chief - Erosion and Siltation Control
Jack White	Plan Reviewer
Ralph Jordan	Plan Reviewer
Conrad Brewer	Department of Public Works
Jack Rinker	Long and Rinker Consultants
Richard Patten	Patten, Harris and Rust Consultants
Joe Bagleo	Parson, Brinckerhoff, Quade and Douglas Consultants
Arthur Nauman	Technical Director - Northern Virginia Builders Association

APPENDIX C

CHICAGO, ILLINOIS

The following case study covers the area in and around the Chicago Metropolitan Area under the jurisdiction of the Metropolitan Sanitary District of Greater Chicago.

General Topography of the Chicago Area (1)

The Chicago area is relatively flat and rolling. Ridges and divides are generally not distinct, and in effect are high-elevation plains.

The streams generally flow parallel to the lake shore. Most of the gradients are low; the streams wander in their courses and some often reverse direction of flow. The area is spotted with ponds and sloughs. Some of the streams flow in shallow beds and have wide flood plains and in only a few places have the streams eroded a prominent course.

Major Drainage Basins (1)

The Chicago area, as considered in this case study, consists of four major natural drainage basins. These basins and their subdivisions are shown on Figure C-1.

The Chicago River system with its north and south branches drains basins (1) and (2), almost all of the City of Chicago, and many of the northern suburbs. The natural course did flow into Lake Michigan at downtown Chicago, but the course has been reversed and the basin now drains out the South Branch.

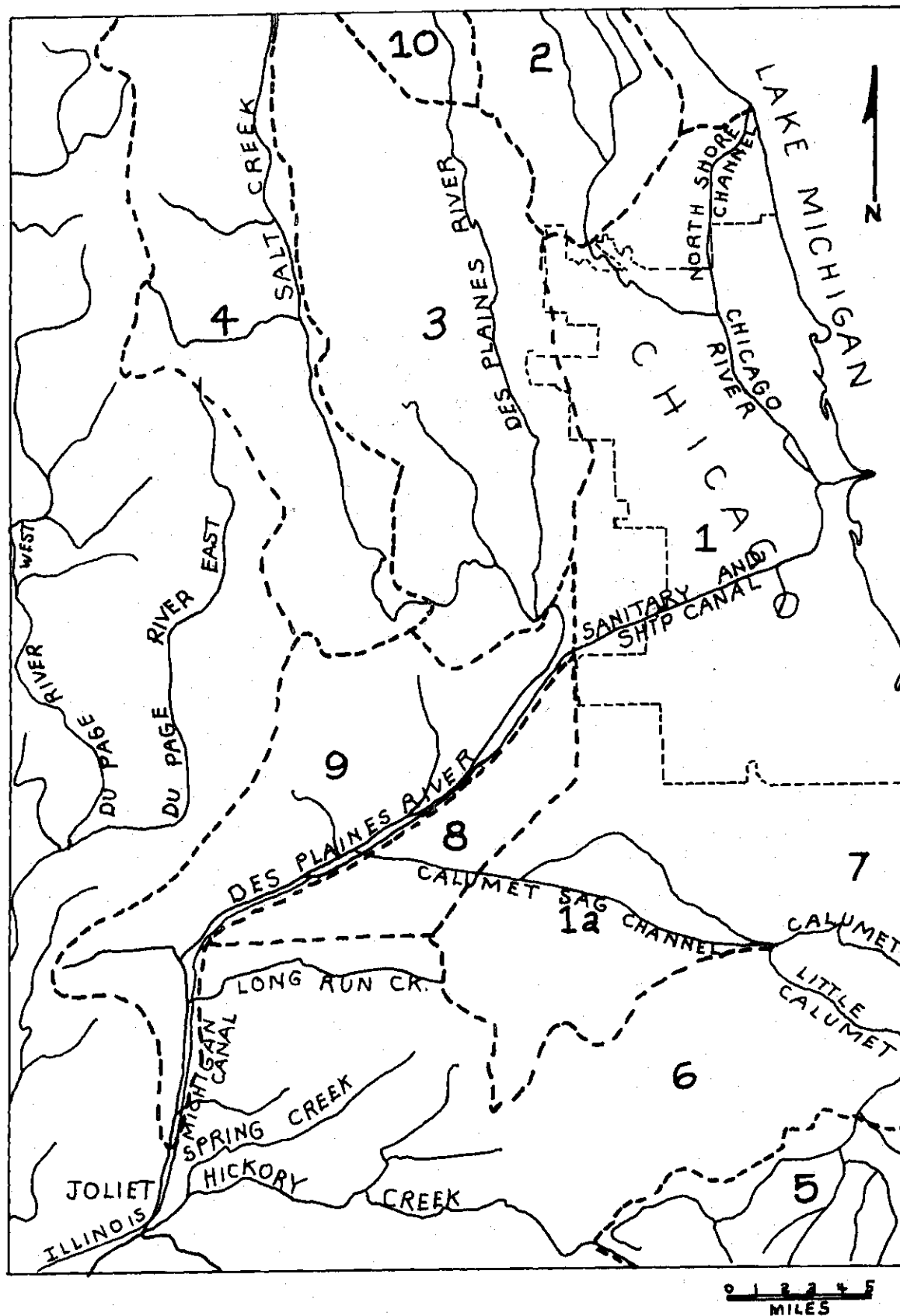


Figure C-1. Chicago, Illinois - Major Drainage Basins

The DesPlaines River basin (portions of which are shown as areas 3, 4, 9, and 10 and Figure C-1) is flanked by the Chicago River basin on the east, and the Du Page and Fox River basins on the west. The source of the river is in Racine County, Wisconsin, and the mouth is at the Illinois River, below Joliet, Illinois.

The Calumet River basin (areas 4, 6, 7 and a part of 1a) lies near the southern perimeter of Lake Michigan. The Grand and Little Calumet Rivers parallel the lake, and have their confluence at the Calumet River. These rivers have been reversed and flow out the Calumet-Sag Channel. Formerly, they discharged to Lake Michigan at 90th Street.

Lake Michigan and some of the contiguous land area is considered to be the fourth drainage basin.

These four drainage basins have been subject to man-made changes and rerouting. However, although the outlet patterns have been greatly remodeled, the areas contributing to them have remained the same, except for areas along the Calumet-Sag Channel and areas in Indiana on the upper reaches of the Grand and Little Calumet Rivers.

Drainage History (2)

The direction of the natural drainage of the Chicago area is divided along a line roughly paralleling the Lake Michigan shoreline, lying from three miles in the north to ten miles in the south, from the shoreline. The easterly streams flow into Lake Michigan which is a part of the St. Lawrence River system. The westerly streams are part of the Mississippi River system.

Sewerage and waste water from the Chicago area was originally deposited into the streams which followed natural courses to Lake

Michigan. Lake Michigan, in addition to being a basis for industrial and commercial vitality, is the source of most of the Chicago-area water supply. Epidemics and threats of epidemics of water-borne diseases in the mid and late 1800's necessitated a constant effort to maintain a pure water supply.

The Illinois and Michigan Canal, constructed during the period 1836-1848 as a navigation link between Lake Michigan and the Illinois Waterway, did draw water out of the South Branch of the Chicago River for navigation purposes. This withdrawal had little effect upon the diversion of waste waters away from Lake Michigan because of the small hydraulic capacity of the I & M Canal. Due to the growth of rail transportation, the I & M Canal was used relatively little after 1870. In the 1840's another canal was constructed linking the South Branch of the Chicago River with the Des Plaines River near Riverside. This ditch, called the Ogden-Wentworth Ditch, received waters from the South Branch via a pumping station. This water then flowed westerly and into the Des Plaines River. Use of this facility did help in the diversion of waste water from Lake Michigan, but more significantly, prevented stagnant conditions in the South Branch of the Chicago River during times of low flow. During a large storm which hit the Chicago area in 1885, flood waters backed up through this Canal from the Des Plaines River into the Chicago River system, and thence into Lake Michigan. This storm made it obvious that the methods of diversion used up until this time were insufficient insofar as preventing pollution of Lake Michigan and insufficient in preventing overflow from the Des Plaines River which caused flooding in the Chicago area. Thereafter, the Sanitary District was formed and

the great works of improvement were undertaken, which caused the reversal of the River systems which emptied into Lake Michigan in the Chicago area.

The Sanitary and Ship Canal, opened at the turn of the century (1900), provided an outlet for the maximum diversion predicted at that time. This great project effectively reversed the flow of the Chicago River, and carried its discharge through the Des Plaines River valley to the Illinois waterway. The later (1936-1938) construction of the locks at the mouth of the Chicago River created a positive control to prevent waters of the Chicago River from flowing into Lake Michigan. In addition, the construction of the Calumet-Sag Channel (1916-1922) provided an outlet for the Calumet River system.

The storm of October 1954, was the first instance since construction of the Chicago River lock when these channels were inadequate to carry drainage away from Lake Michigan. Three years later in 1957 there was another storm large enough that it was necessary to relieve flooding by allowing some of the runoff to flow into the Lake. Since 1957, storm discharge to the Lake has occurred with increased frequency.

Many other channel developments have been made for the improvement of flow in the drainage system. The North Shore Channel (constructed 1908-1910) allowed dilution (with flusing water from Lake Michigan) of waste water discharged in the North Branch from the industrialized north side of Chicago, thereby maintaining flow in the North Branch of the Chicago River. At the downstream end of the Chicago Sanitary and Ship Canal, a hydroelectric power plant was built by the Sanitary District to develop a resource which was made available by virtue of the construction

of the Canal and the diversion of Lake Michigan water. The power plant had a rated capacity of 28,000 horsepower. In addition to the power plant, a lock was installed for waterway navigation and control gates provided for release of storm water when discharge in excess of the capacity of the power plant was required.

The Chicago River has been improved to make it more suitable for navigation. The Calumet Rivers has also been improved for navigation. These improvements have also been improved for navigation. These improvements have had an auxiliary effect of improving runoff capacity.

Diversion from Lake Michigan, through the channels of the Sanitary District, was designed on the basis of 3.3 cfs per 1,000 population. The Channel was designed to accommodate 10,000 cfs which allowed for an ultimate population of 3,000,000 people. In 1909, a Treaty was signed by the United States and Canada which allowed for a maximum diversion of 10,000 cfs at Chicago. In 1925, litigation was begun by other Lake States to reduce Chicago's use of Lake Michigan water. The litigation resulted in a decree which reduced the water available to the Sanitary District and required the construction of Treatment Plants and the building of a lock at Chicago Harbor. Allowable diversion was reduced in successive stages to an annual average of 1500 cfs, beginning on January 1, 1938. Except for brief periods, this annual average has remained and has been adhered to until February 28, 1970. Litigation which began in 1959 resulted in another court decree handed down in 1967. This decree provided for an allocation of 3200 cfs Lake Michigan water, on the annual average, to the State of Illinois, beginning March 1, 1970. While the diversion was significantly increased, it is only an apparent increase as the new decree

included within the total both domestic, dilution, and the storm runoff water. Prior to that, the 1500 cfs limit included only dilution and storm runoff water. Actually, the 1967 decree resulted in no additional water for the Sanitary District or the State of Illinois. It did provide, however, that the State must use this water in the best possible way and exhaust all feasible means of exploiting other water resources and conserving existing resources before asking the Court for an increase in the diversion allotment. This may result in a reduced allowance to the Sanitary District for dilution purposes as the demand for domestic water increases.

History and Functions of the Metropolitan Sanitary District
of Greater Chicago (2)

The Sanitary District of Chicago was originally organized under an act of the General Assembly of the State of Illinois, dated May 29, 1889. This act has been amended from time to time increasing or modifying the power of the District. In 1955 the name was changed to The Metropolitan Sanitary District of Greater Chicago (hereafter referred to as the Sanitary District). The Sanitary District now encompasses 90% of the area and 99% of the population of Cook County, Illinois.

The Sanitary District is governed by a board of nine Trustees elected by the voters. Three are elected at large every two years for six year terms. The Board of Trustees elects from its membership a President and a Vice-President. The President has the power of veto over the ordinances passed by the Board.

The main function of the Sanitary District is keeping sewage pollution out of the water supply and collection and treatment of sewage to

avoid contamination of the Chicago, DesPlaines and Illinois Rivers. It exercises control over local sewerage systems but ownership, construction and maintenance of these facilities is left to municipalities or utility companies. It does, however, provide the main trunk lines for the collection of sewage from local systems together with the treatment and disposal thereof.

In addition to guarding the streams and waterways against pollution, the Sanitary District has authority to assume some responsibility for providing adequate facilities to handle storm-water runoff within the area under its jurisdiction. The Sanitary District is supported by direct taxation and may issue bonds for permanent improvements. It also has the power of eminent domain and police power.

The Sanitary District originally comprised an area of 185 square miles with a population of 1,150,000 people. Today the Sanitary District comprises an area of 860 square miles and has a population of nearly 5,500,000 people. To this latter population figure could be added another 3,500,000 people representing a population equivalent for the industrial waste now being treated by the Sanitary District.

The original area was made up of the City of Chicago, Oak Park, Cicero, Berwyn, Stickney and part of Lyone Township. Annexations have been made in 1903, 1913, 1917, 1919, 1921, 1927, 1949, 1945, 1947, 1949, 1951, 1953, 1955 and 1956. All of this annexed territory has been within Cook County.

History of Flooding in the Chicago Metropolitan Area (2, 3)

The Chicago area - because of its unfortunate topographical setting, rampant growth and inadequate regulatory authority - is perhaps

one of the most severely flood plagued urban areas in the world. This area has suffered from flood damage with increasing frequency from the time the original settlers first inhabited this area.

One of the first major floods of record occurred in March, 1849, and resulted in considerable damage to ships and bridges along the Chicago River. This particular storm was further complicated by ice jams in the river which contributed greatly to the damage. The storm of August, 1885, although not particularly destructive to property in the Chicago area, did carry a large volume of debris and filth out into Lake Michigan thereby polluting the water supply. The public's reaction to this condition resulted in the formation of the Sanitary District of Chicago in 1889 as previously discussed.

In the past twenty-five or thirty years, due to the extensive growth of this area, the runoff from rain storms has increased about two and one-half times. There have been no improvements in the main channels, however, since their original construction. Coincidental with the increase in runoff has been the occurrence of several major storms, one in 1954 and another in 1957, which were of a magnitude that should be expected no more frequently than once in a hundred years.

The annual average flood damages including sewer back-up, is approximately 30 million dollars and affects 50,000 homes. Money damages and numbers of homes are only part of the trouble. Perhaps as significant is the lowering in the quality of life, public and private inconvenience, and widespread fear and anxiety when a storm is predicted.

The stream beds that carry this additional runoff remain essentially the same now as when the area was originally settled. They have been

constricted, however, by the construction of numerous bridges, culverts, etc., and by encroachments upon the natural stream beds and flood plains by housing developments and other construction. The flow in these streams has been further constricted by an accumulation of alluvial deposits, trees, and debris, and by the dumping of refuse within the stream bed. Numerous swampy areas which previously provided storage capacity for the streams during floods have been filled in and used for buildings or other purposes.

Partly because of these constrictions the streams and channels of the Sanitary District are incapable of carrying the storm runoff during heavy storms. The high-water stages of the streams often inundate the combined sewer overflow outfalls and storm sewer outfalls. As a result, sewage water backs up into basements and streets in commercial and residential areas.

The rapid development of the rural areas of Cook, Will, and DuPage Counties for residential and commercial purposes is compounding the drainage problem. These developments have radically changed the runoff characteristics of these areas. Large paved surfaces, roofs, streets, etc., increase both the volume and rate of storm water runoff. In most areas, the existing sewer systems were not designed for this rapid growth and consequently do not provide the means of handling this increase in storm runoff. Many new residential developments are in areas where natural drainage is extremely poor. These developments have been planned with little or no regard for providing adequate drainage facilities for storm water runoff.

Drainage problems for some communities are compounded by

residential and commercial developments outside their corporate limits. Originally, the natural drainage from the outlying unincorporated areas passed into or through the incorporated community and the sewer system was designed to take care of this "natural" runoff. However, as these outlying areas are built up, the rate of runoff increases and soon overtaxes the sewer system with resultant flooding of previously unflooded areas. Without new legislation there is no apparent, generally accepted means of compelling areas outside the corporate limits to bear part of the cost of enlarging or improving the affected drainage system.

Numerous drainage districts were formed in early years for the express purpose of providing agricultural drainage. In certain instances these drainage districts have been found to be a contributing cause of drainage problems farther downstream. In providing adequate drainage within the district during storm conditions, an increased rate of flow is discharged into the outlet stream. The stream in many cases is inadequate to carry the extra water and lands flood farther downstream.

The Sanitary District has designed its intercepting sewers to handle 150% of the normal sanitary flow, which is determined from past records of average flows. When flow exceeds this amount due to storm runoff, the excess is automatically diverted into rivers and canals adjacent to the community where the storm water originated. A frequent complaint is that these diversion structures sometimes jam and cause inundation of local sewer systems. Often, when the river or canal is at flood stage, it causes backup, with resultant flooding in the storm area.

The Chicago River, Little Calumet River, Cal-Sag Channel, and the Chicago Sanitary and Ship Canal provide little storage capacity above

normal water elevation. The normal level must be maintained for navigation. Therefore, it is evident that flooding is likely and does occur. In the lower reaches of the river the water level is lowered in advance of anticipated storms to increase hydraulic gradients and hence discharge rates. The lowering of this water level in advance of storms has been standard operating procedure of the Sanitary District for some time.

Causes of Flood Damage (2)

The greatest flood damage is caused by water backing up into basements from sewers or drains. This causes extensive damage to property stored in the basements as well as to motors of appliances and heating equipment. In some buildings, the water causes major damage to recreation rooms, depending upon the type of flooring and paneling.

In some instances, the capacity of a sewer system is overtaxed causing the water to overrun curbs and lawns, and to enter the basement through the windows or the upper levels through doors. This situation occurs frequently in some areas, especially in the fall when street drains may be clogged with leaves or other debris.

Damage is often done to property as a result of water pressure exerted against building walls or basement floors, causing water seepage into the building or causing a cracking, bulging, or disintegration of walls or floors. In many areas, especially in the southern portion of Greater Chicago, water has risen to floor levels of many dwellings thereby ruining furniture, rugs and other household articles.

Viaduct and street flooding causes much damage to buses, automobiles, street cars and trains. The additional expense of having traffic halted or re-routed, at much inconvenience to the public, could be added

to specific property damage in this instance.

Numerous communities outside the Sanitary District's boundaries utilize the streams for the disposal of effluent from their sewage disposal plants. During high water these local plants are often inundated by water backing up through their outfall sewers. This creates a critical health hazard due to the possibility of raw sewage seeping into the water supply systems, reducing efficiency of the plants, and polluting storm water. In addition, there would be a general nuisance from such a situation.

Flood-Hazard Mapping in Metropolitan Chicago (4)

In an effort to indicate which areas within the Chicago Metropolitan area have the greatest potential of being affected by flooding, a flood-mapping program financed jointly by the six counties of Metropolitan Chicago (Cook, DuPage, Kane, Lake, McHenry, and Will), the Northeastern Illinois Planning Commission, the State of Illinois, and the U.S. Geological Survey was undertaken in 1961. This unique flood-mapping program has resulted in maps, showing the flood hazard of nearly the entire six-county metropolitan area.

A flood-hazard map uses as its base a standard U.S. Geological Survey 7-1/2 minute topographic quadrangle which includes contours that define the ground elevation at stated intervals. Each of the quadrangles covers an area of approximately 57 square miles. The area inundated by a particular "flood of record" is superimposed in light blue on the map to designate the "flood-hazard area". Also marked on the flood-hazard map are distances (at 1/2-mile intervals) along and above the mouth of each stream and the locations of gaging stations, crest-stage gages, and

drainage divides.

Accompanying the flood-hazard map are explanatory texts, tables, and graphs, which facilitate their use. One set of graphs shows the probable frequency of flooding at selected gaging stations. These graphs indicate the average interval (in years) between floods that are expected to exceed a given elevation. Frequencies can also be expressed as probabilities which make it possible to express the flood risk or flood hazard for a particular property; for example, a given area may have a 5 percent chance of being inundated by flood waters in each year.

This flood-mapping program was carried out in three phases. The first phase extended from July 1, 1961 to June 30, 1966. In phase one of the program, flood maps were prepared for 43 7-1/2 minute quadrangles in the six-county area. This constitutes about 70 percent of the total area that has been mapped to date or 60 percent of the total six-county metropolitan area. Because of insufficient hydrologic data in much of the area, it was necessary to establish 229 crest-stage gages to record instantaneous flood peaks so that flood profiles and flood-plain limits could be better defined along the approximately 1,000 miles of streams located in the 43 quadrangles.

The second phase extended from July 1, 1966 to June 30, 1969. This phase involved the preparation of 19 additional flood maps. As in the areas mapped in phase one, it was necessary to establish 165 crest-stage gages within these additional areas. In addition, the crest-stage gages established as part of phase one were kept in operation as part of phase two, to extend the hydrologic records.

The completion of phase two made flood maps available for the

entire metropolitan area with the exception of the western part of McHenry County and the completely urbanized area of Chicago and the close-in suburbs in Cook County.

Phase three of this project, which is currently in progress, has four major objectives:

1. continued operation of the existing network of crest-stage gages,
2. evaluation of the crest-stage gage network for adequacy and relevance,
3. extension of the program to unmapped areas,
4. periodic and systematic revision of the flood maps prepared in phases one and two.

The U.S. Geological Survey states that, "continuation of the co-operative flood-hazard mapping program along these lines will assure that local governmental bodies, industries, utilities, developers, and citizens of Metropolitan Chicago will have more and better flood information which can be used in furthering the region's orderly development."

Flood Control Activity by the Metropolitan Sanitary District (3)

The most prominent agency in flood control work in the Metropolitan Chicago area is the Sanitary District. It has thrust itself into the void created by the inactivity of others, and assumed as a secondary function that of flood control, along with their primary functions of collection and treatment of wastewater and water quality standard enforcement.

In the regulatory area, the Sanitary District has required the local zoning authorities, Village and the County, to enact flood plain

ordinances. The Sanitary District requires these ordinances before they allow an area to connect to their sanitary sewer system. These ordinances do safeguard flood plain developments against highwater but do not provide for the preservation of natural storage. The Sanitary District has recently required on-site detention of excess runoff from developments. The Sanitary District has used its control of permits for sewer connections to require these regulations. As a result, compliance has come easily. These requirements are necessary but also, admittedly, only brakes on the growth of flooding problems. They must be complemented with a program to solve the existing problems.

Currently, the Sanitary District estimates the remedy for the flooding problems in the separate sewered and unsewered area within their jurisdiction to be in the 200 to 300 million dollar range. A master planning effort is now underway to prepare a plan which will define these needs. This plan, called the Chicago Metropolitan Area River Basin Plan, is being undertaken through a cooperative agreement between the Sanitary District and the Soil Conservation Service. The Sanitary District has provided a major part of the early funding in order to get the Soil Conservation Service on the job immediately rather than to wait for fuller Federal Budgeting. The Sanitary District estimates that planning should be completed by 1976.

Under this work, the total 1200 square mile area is divided into six watersheds draining the Metropolitan area. These watersheds include North Branch of the Chicago River, Little Calumet River, Calumet-Sag Channel, Poplar Creek, Salt Creek, and DesPlaines River. They are the watersheds in Cook County and the watersheds with streams flowing into Cook

County. The study will determine the water and related land resource problems, needs, and purpose, and evaluate solutions and alternatives to problems associated with watershed protection, flood damage reduction, urban water management, fish and wildlife, recreation, water quality, environmental enhancement and other related purposes. In addition, the extent to which action is needed beyond the scope of available going programs will be determined.

The planning procedures and methods used by the Soil Conservation Service are somewhat unique. The prime input in the planning are the problems and needs expressed by Steering Committees (composed of local governments, interest groups, and citizens). These Committees are not used passively. Rather the situation is reversed and the Committees are asked to take a lead role wherein they define problems, needs, planning criteria, planning priorities; assist in defining alternatives and review the alternatives to select a final plan.

The work performed by the Soil Conservation Service can best be described as technical assistance. They advise the Committees on engineering problems, make the necessary investigations and analyses, determine the economics, prepare the technical aspects of the environmental impact statement, and write and publish the reports, maps, etc., necessary to define the final plans. The Soil Conservation Service also provides the liaison and coordination with other technical agencies so that proper consideration and inclusion is taken of other programs, technical information and studies.

One plan has been completed under this study which gives some insight into the kind of information that can be expected from this study.

This plan, the Upper Salt Creek Watershed Work Plan, covers a 33,280 acre area primarily in Cook County, with small areas in Lake and DuPage Counties, Illinois. The study reveals that approximately 1,940 acres within this watershed are presently subject to flooding. In addition to this large area being affected, there are 1,200 residences within the flood plain that are affected by flood waters. Sixty-five percent of these residences experience some flooding within the basement or the lower level of the structures caused by submerged storm sewer discharge points and floodwater entrance into the sanitary sewer system through flooded street manholes.

An estimated thirty percent of these residences are subject to the direct entrance of surface floodwaters into lower level garages, basements, and subground living areas. Finally, an estimated five percent of the flood plain homes are presently vulnerable to flooding by inundation of the frame portions of the structure.

In addition to the residential damages, flooding occurs on parking areas, playgrounds, highways and streets, etc., which poses public inconvenience, neighborhood degradation, and a lowering in the quality of life.

Developed areas occupy 54.8 percent of the watershed area. Residential areas occupy more than half of the total developed area and vary greatly as to cost and density. With the exception of one large forest preserve, most lands in the flood plain are privately owned. There are publicly owned flood plains in Elk Grove Village and Rolling Meadows which include school and church playgrounds and parking areas, parks, and other public recreation facilities.

Projected future flood plain buildup will result in increased average annual damages. The following summarizes present and projected floodwater damages.

AVERAGE ANNUAL FLOOD DAMAGES
IN SALT CREEK WATERSHED (3)

<u>Dollars</u>			
	<u>Present Buildup</u>	<u>Future Buildup</u>	<u>Total</u>
<u>Items</u>			
<u>Direct damage</u>			
Residential	304,600	269,200	573,800
Commercial	300	98,200	98,500
Other urban	1,500		1,500
<u>Indirect damage</u>	106,200	73,500	179,700
Total Damages	412,600	440,900	853,500

In order to control the flooding within this watershed, the planned measures consist of five floodwater retarding structures, one multiple-purpose (flood prevention - recreation) preserve, approximately 1.8 miles of channel improvement, and a land treatment program for at least half of the watershed. Costs for these measures are estimated to total \$24,500,000. In addition local landowners, groups, and villages will install and maintain land treatment measures in accordance with their agreements with the local Soil and Water Conservation District.

The people of Upper Salt Creek Watershed recognized the need for a comprehensive approach to the solution of watershed problems. The sponsoring local organizations and the Soil Conservation Service agreed to the following specific objectives:

1. Reduce erosion and increase rainfall infiltration by establishing land treatment measures which contribute directly to

watershed protection and flood prevention.

2. Attain a reduction of 85 to 90 percent in average annual flood-water damages in urban areas with consideration given to the 100-year frequency storm.
3. Include recreation water in one of the structures and increase maximum design capacity of associated recreational facilities for public use which would include a wide range of recreational activities because of the tremendous pressure from the metropolitan area.
4. Include water resource improvement for recreation and/or wildlife in all suitable areas in order to improve the local environment and make the watershed a more aesthetically desirable place in which to live.

Although planning investigations indicated several alternative solutions to the flooding problems, it was agreed that flood water storage was the most acceptable means of reducing these damages. It was also agreed that undeveloped flood plain areas should be allowed to develop only as defined in the Plan. It was recognized that channel improvement might be needed to provide the desired protection in selected areas.

State Participation in Flood Control

In addition to the above, the Sanitary District has been very active in trying to get the State of Illinois to enact and enforce some state regulations pertaining to flood control. Quoting from the Recommended Resolution for Regulation and Control of Storm Drainage which Affects Separate Sewered and Unsewered Areas of the Metropolitan Sanitary

District of Greater Chicago:

Therefore be it resolved, that the President of the Metropolitan Sanitary District of Greater Chicago hereby petitions the Governor of the State of Illinois to direct the appropriate department of the State of Illinois to:

- (1) Establish a flood control program for the State of Illinois based on the principle of retaining storm water runoff at or near its source, and
- (2) Regulate and control storm flows which pass from one county to another within the State Illinois by establishing maximum flows at the county lines; and

Be it resolved, that the Metropolitan Sanitary District request the State of Illinois through its Department of Public Works and Buildings to regulate and control storm water runoff from all improvements in the drainage basin including federal, state and local road improvements, by requiring that all permits issued by the Department of Public Works and Buildings for drainage improvements including the mandatory requirement that permittees construct and maintain storm retention facilities capable of storing runoff from the storm of record.

In addition the Sanitary District has requested the Governor of the State of Illinois to direct the appropriate departments of the State government to initiate inter-state agreements for the regulation and control of storm flows entering the State of Illinois.

The State has passed a flood plain act to regulate construction in flood plains via a permit system but this act has had little or no enforcement. The Sanitary District is anticipating that the State will play a greater role in flood control in the future but at present their participation is limited.

Blue Ribbon Sub-Committee on Flood Control

In a further effort to establish some policies and guidelines with regard to flood control, the Sanitary District participated in a "blue ribbon committee" concerned with flood control problems. This committee was made up of representatives from the Sanitary District, consulting

firms, contractors, developers, public works personnel, and interested citizens. Following are some statements issued by this committee regarding flood control in the Chicago Metropolitan Area.

The region-wide or basin-wide flooding problems within the Chicago Metropolitan Area result from a number of causes, for example, unrestricted flow from upstream areas outside of the jurisdiction of the Metropolitan Sanitary District, improperly maintained streams, increased runoff from road sewers and drainage ditches, culvert and bridge openings which restrict the storm water flow rates, as well as others, all cause flooding. The solution to these basin-wide and region-wide flooding problems cannot be accomplished through the sewer permit ordinance, but must be performed by the responsible governmental bodies. On the other hand, the Sewer Permit Ordinance (which will be discussed in the next section of this report) can be used to exert pressure on local governments and developers to jointly participate in providing detention storage to reduce the excessive runoff during heavy storm periods from the headwater areas.

It is not the intent of the Sub-Committee that numerous small puddles and ponds be constructed throughout the Metropolitan Area. Such scattered ponds may create nuisance and possible health hazard and fail to provide flood protection if not adequately maintained. Rather, the purpose of the recommended amendment to the Sewer Permit Ordinance is to encourage the development of well maintained landscaped lakes to act jointly as detention reservoirs and recreation facilities or aesthetic focal points in new village parks, either in incorporated or unincorporated areas, forest preserve areas, county parks, housing developments, shopping centers, and industrial parks. Also, considerable storage of storm water can be provided at its source without undue nuisance if properly engineered; for example, detention on flat roofs, parking lots, gutters, yards, underground storage, etc.

The Sub-Committee believes that the Federal, State, County, Metropolitan Sanitary District and other local agencies, should work together to provide overall planning, scheduling and funding for the large drainage basin projects.

To summarize, the Blue Ribbon Sub-Committee recommends a three fold attack on the drainage problems in this region:

1. The establishment of a "Flood Control Coordinating Committee" which would set responsibility, provide budgeting and set policy on flood control improvements on a region-wide

basis.

2. Continue to establish the Basin Steering Committees to develop the planning of flood control facilities on a basin-wide basis.
3. Passage of the proposed amendment to the Sewer Permit Ordinance which would control the excessive runoff from the headwater areas. (This amendment has been passed and made part of the Sewer Permit Ordinance.)

Metropolitan Sanitary District Ordinance and Regulations

The Sanitary District has issued a sewer permit ordinance, guidelines for flood damage prevention ordinance and a manual of procedures for the administration of the sewer permit ordinance. Although the State of Illinois has not given the Sanitary District any specific powers to enforce flood and drainage ordinances, the Sanitary District has used its powers in the area of sewage collection and disposal to encourage compliance with their guidelines for flood damage prevention. Most of the local municipalities want to use the Sanitary District's sewage disposal system in lieu of creating their own system and thus they have complied with the Sanitary District's request. Following is a brief discussion of the areas covered in these documents.

Sewer Permit Ordinance

This ordinance covers the following:

1. Limits construction of sewers unless areas have drafted and adopted a storm water detention or flood control ordinance acceptable to the Sanitary District, including a drainage plan and time schedule for its implementation approved by the Sanitary District.
2. In lieu of the above the area can obtain the needed sewer

construction if detention storage is provided so that the runoff from proposed developments is not greater than that from the sites in a natural or undeveloped state.

3. In addition to the above the Sanitary District has proposed an amendment to this ordinance regulating filling in flood plain areas. This amendment would require that compensatory flood plain storage be provided to compensate for any proposed filling in the flood plain so that the filling would not adversely affect the efficiency or capacity of the flood plain area.

The first two items listed above have been the "power" behind the Sanitary District's flood control program. Since the local communities are most anxious to obtain permits for construction, operation and maintenance of sewerage systems designed to discharge directly or indirectly into collection and treatment facilities of the Sanitary District, there have been no problems in getting these communities to abide by these provisions.

The Sanitary District had hoped that communities would develop a drainage plan for the entire community but none have been completed at the time of this study. Several communities are working on drainage plans but it has been easier for the communities to restrict the runoff rate from developed areas than develop a comprehensive drainage plan.

Manual of Procedures for the Administration of the Sewer Permit Ordinance

Following are the major areas included in this manual:

1. all construction within the flood plain areas must conform to the requirements of the local flood plain ordinance,

2. the flood crest elevation and the limits of the flood plain area are based on the USGS maps,
3. comprehensive basin-wide planning for flood control is encouraged,
4. detailed regulations and design criteria concerning storage and controlled release of storm water runoff are given.

The design criteria given in this manual were arrived at by the Blue Ribbon Sub-Committee. This sub-committee was aided in its work by a technical staff made up of personnel from the Sanitary District. This technical staff presented several recommendations and proposals of a technical nature, of which some were adopted and some were changed. There were also several compromises within the sub-committee. As an example some of the members of the sub-committee wanted a storm of two year frequency to be used for the outlet design for on-site storage while others felt that a storm of five year frequency would be better. As a compromise the sub-committee selected a storm of three year frequency. Thus the political process was active during the selection of these design criteria.

Sanitary District Suggested Guidelines for Flood Damage Prevention Ordinance

All proposed local ordinances must conform with the requirements given in these guidelines for Sanitary District approval.

1. The flood hazard maps prepared by the USGS show the minimum elevations to be used for delineation of flood plain areas.
2. Regulations are given concerning development within flood plain areas (including regulations on sanitary sewers).

3. These guidelines discuss flood control provisions and flood-proofing structures within flood plain areas.

In addition, the Sanitary District and the Northeastern Illinois Plain Commission have drafted suggested flood damage prevention ordinances which have been used as model ordinances by the local communities. These ordinances give detailed regulations pertaining to flood control including a time schedule for implementation of an ordinance, establishment of a 100-year flood plain, maintenance of drainage system, plans and studies required, requirements for filling in flood plain areas (compensatory storage), storage of materials in flood plain areas, and storm water detention storage.

Adopted Local Ordinances

Although the Sanitary District requires that each local community adopt a flood control ordinance, the local community establishes its own engineering design criteria. The one area in which there has been some disagreement among the local communities is that of choosing a design storm for the design of drainage facilities. Communities have selected everything from a five to a twenty-five year design storm with most adopting either a five or ten year storm. From the results of interviews with local engineers and other people dealing with drainage problems, it was concluded that there wasn't any definite rationale used when selecting the design storm. Personal preference, compromise, or adopting what some other nearby community was using played the major role in determining what design storm would be used.

Since the Northeastern Illinois Planning Commission published its Suggested Flood Damage Prevention Ordinance in 1972, the local ordinances

written since that time have, by and large been carbon copies of this suggested ordinance.

Hydrology and Detention Storage

Within the jurisdiction of the Sanitary District, the design of drainage facilities is left up to the local communities. The Sanitary District does check and approve these designs but the selection of design methods is a local decision. When any new development is proposed, the Sanitary District requires a detention review study to determine whether detention storage is required. In addition, when the Sanitary District feels that a proposed development might cause drainage problems, a hydrologic and hydraulic study is required.

Hydraulic Studies

The local communities use the rational method almost exclusively in designing their drainage systems. They also use the rational method for designing the required detention facilities. The Sanitary District has developed a procedure for determining allowable release rates and required flood storage for detention facilities which is used by the local communities. This procedure uses rectangular hydrographs, of varying duration, which are routed through the proposed detention storage to determine what storm duration is critical. This critical duration is then used to calculate the maximum storage needed for a certain development. The engineers with the Sanitary District, who were interviewed as part of this study, felt that although they were introducing errors by assuming rectangular hydrographs, the rational method was not accurate enough to justify a more sophisticated approach. They also felt that their assumptions were on the conservative side.

In developing this procedure, the Sanitary District was looking for a procedure that would not be difficult for local municipalities and engineers to understand and use. Thus for ease of use and administration the Sanitary District feels their procedure is adequate for the purpose intended.

Restrictions on Retention Storage

There are several restrictions that the Sanitary District has placed on the design of detention storage that are of some interest. In the design of the detention facilities, storage must be provided for the increased runoff from the proposed development (using a 100-year design storm) and a bypass or outlet must be designed to handle the remainder of the outflow from the development plus the runoff upstream, assuming the upstream area is fully developed according to the present zoning restrictions (using a three-year design storm).

When it is determined that detention is required, this storage must be provided even if there is excess storage capacity available in the natural drainage system. It has been the experience of the Sanitary District that in most cases the natural storage is already being used by the storm runoff from existing developments.

Although the Sanitary District does not require detention on some small developments, they do keep records of who is developing what areas. In this way if a developer tries to develop a large site in small developments to avoid the detention requirements, the Sanitary District will total all these small developments and require the developer to provide detention storage for the total development.

Flow Simulation Model

The Sanitary District has developed a flow simulation model for the Chicago Metropolitan Area (6). To date, this model has only been used internally by the Sanitary District to check the designs of large reservoirs and drainage facilities associated with large developments. The model has not been used by the local communities or consulting engineers in their original designs.

The Sanitary District's Model has been used primarily to simulate individual design storms and not to simulate frequency curves. The Sanitary District has used the model to check some of the work that Hydrocomp, Inc. did on the North Branch of the Chicago River, with good correlation between the results obtained by Hydrocomp and the Chicago Model. In addition the District has checked the model against empirical data from individual storms with good results. They have also run one year of simulation on a few small watersheds with good results.

The District plans to continue developing their model and hopes that it will play an even more active role in the design of drainage facilities in the future.

Additional Aspects of the Flood Control Program in the Chicago Metropolitan Area

Following is a list of some additional aspects of the flood control program in the Chicago Metropolitan Area that were of some interest in this study.

1. There are no erosion and sediment control ordinances in the Chicago Metropolitan Area but the Soil Conservation Service is doing some work in this area.

2. Dumping in the flood plain is controlled by the State Environmental Protection Agency where there is a possibility of a pollution problem.
3. Some communities allow filling in the flood plain (about 20 percent of the 125 communities) but most do not. Those communities that do allow filling require that compensatory flood plain storage be provided for that which is lost as a result of the filling.
4. The local communities maintain the drainage system within their jurisdiction while the Sanitary District maintains the rest of the system. The only exceptions are a few large planned unit developments where developers have agreed to maintain the drainage systems within the developments. The Sanitary District encourages developers to centralize their detention storage facilities for ease of maintenance.
5. Preventive maintenance of the drainage system consists of cleaning debris from the system and alleviating small problems as they arise. There is no systematic checking of the drainage system.
6. Detention facilities are used for flood control and recreation and are not used for ground water recharge because of the clay soil in the Chicago Metropolitan Area. Because of the flat topography in the area, most of these facilities are simply holes in the ground and thus structural considerations are not of great importance.
7. The 100-year flood plain elevations have been established for

only about five percent of Cook County but the Sanitary District hopes to establish these elevations for the entire County. The 100-year flood plain would then be used instead of the flood plain areas established by the USGS mapping program.

8. The major loophole in the Sanitary District's flood control program involves those developments that do not need sewer installations. Highway construction, parking lots, etc., result in large impervious areas which are built without detention storage. The local communities can control parking lots and other local developments but only the State can control the major highway construction and it has thus far seen fit not to.

Concluding Remarks

In Illinois the individual communities and villages are politically very powerful and autonomous. It has been very difficult to coordinate the flood control efforts of these communities into a cohesive flood control program. Each community sets up many of its own restrictions and regulations and thus there are no common standards for all the communities to adhere to. In addition many of the watersheds in Cook County overlap into adjacent counties where there are no agencies to coordinate the flood control efforts.

If it had not been for the influence the Sanitary District has because of its sanitary sewer program, it would have been very difficult (if not impossible) for them to have had any impact on storm water problems.

Considering these political and administrative barriers to the forming of a regional flood control program, the Sanitary District has made great progress in coordinating the individual flood control efforts in Cook County. Through their sewer permit system they have initiated flood control ordinances for many of the local communities. They have participated in the formulation of a model ordinance, simulation model, detention storage procedure, and several other procedures and regulations discussed in this case study.

APPENDIX C. REFERENCES

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5. Harza Engineering Company, Westchester-Hillside Flood Control Studies, Chicago, Illinois, May 1971.
6. Lanyon, Richard F., James P. Jackson, Flow Simulation System, The Metropolitan Sanitary District of Greater Chicago, Presented at ASCE Hydraulics Conference, Ithaca, New York, August 17, 1972.
7. United States Department of Agriculture in cooperation with The Metropolitan Sanitary District of Greater Chicago, Cooperative Studies for Preparation of the Chicago Metropolitan Area River Basin Plan, September 1971.
8. Numerous Sanitary District memos, letters, reports, regulations, and ordinances pertaining to drainage.
9. The following persons were interviewed or their opinions were obtained concerning certain portions of the material contained in this case study.

PERSONS CONTACTED IN THE CHICAGO AREA

Metropolitan Sanitary District of Greater Chicago

Hugh McMillan	Assistant Chief Engineer
Richard Lanyon	Head Engineering Flood Control
James Jackson	Associate Civil Engineer (Flood Control)
Paul Griesback	Assistant Head Local Sewers
Vince Flood	Legal Staff of Metro- politan Sanitary District
George Boyd	Legal Staff of Metro- politan Sanitary District
C. T. Blomgren, Jr.	Illinois State Environ- mental Protection Agency
Richard Riley	Research Planning, Northeast Illinois Plan- ning Commission
Byron Prugh	U.S.G.S. Water Resource Division
John Priest	Harza Engineering
Walter Hodel	Consoe, Townsend and Associates
Paul Spies	Ciorba, Spies, Gustafson and Company
Edward Brink	Village Engineer, Village of Alsip, Illinois
Norm Bacon	Village Engineer, Village of Oak Lawn, Illinois
Stewart Mann	Village Attorney, Village of Schiller Park, Illinois
Bill Brazelton	City Engineer, City of Calumet, Illinois
Edward Marquardt	Public Works Department, Village of Palatine, Illinois
Robert Widdicombe, Jr.	Executive Vice President, Home Builders Association of Greater Chicago

APPENDIX D

INGHAM COUNTY, MICHIGAN

Ingham County is one of three counties in the Tri-County Regional Planning Commission. This Commission, an advisory body, was established by a resolution of Clinton, Eaton, and Ingham counties in 1956. It serves 78 governmental units containing three counties, 48 townships, 10 cities, and 17 villages. In the following pages, some general information about the Tri-County region is presented followed by a more detailed discussion of the drainage program in Ingham County.

General Description of the Tri-County Region (1)

The Tri-County Region is located in the southern part of Michigan's lower peninsula approximately equidistant from the two Great Lakes of Michigan and Huron. This region, with a 1970 population of 378,423, is composed of a mixture of diverse types of communities embodied in a total land area of some 1700 square miles. The "hub" of the region is the Lansing-East Lansing urbanized or metropolitan area. The townships surrounding Lansing and East Lansing are urbanizing at a rapid rate and in some cases there has been more than a one hundred percent increase in population during the past decade. Outside the metropolitan area, ten cities ranging in size from 1,000 to 9,000 people are scattered through the region at varying distances from the "hub". In addition, fifteen rural communities dot the region. These cities and villages are separated from the metropolitan area by com-

parably vast rural areas and, in fact, approximately ninety percent of the region's land area is rural in nature.

Topography

The land surface of the Tri-County region is generally flat or gently rolling, a typical topographic characteristic of the southern part of the lower peninsula of Michigan. The land surface of this region slopes gently to the north and west. Hills in the southern part of Ingham County are the highest areas in the Tri-County region. The lowest areas are along the Maple River in northwest Clinton County.

River Basins

There are three major river basins in the Tri-County region; the Grand, Kalamazoo, and Huron (Figure D-1). The majority of the land area in the region is in the upper part of the Grand River Basin and is drained by the Grand River and its tributaries which are the Maple, Lookingglass, and Thornapple rivers. The total drainage area of the Grand River Basin in the region is about 1,557 square miles. An area of approximately thirteen square miles in the southeastern part of Ingham County drains southeast to the Huron River, and in the southwestern part of Eaton County, about 132 square miles, drains southwest to the Kalamazoo River.

Michigan County Drain Commissioner (2)

Because of the unique governmental setup in Michigan, it is necessary to briefly discuss the functions of the County Drain Commissioner and how these functions relate to the County's Drainage Program.

The Drain Commissioner's office was created in Michigan in 1859

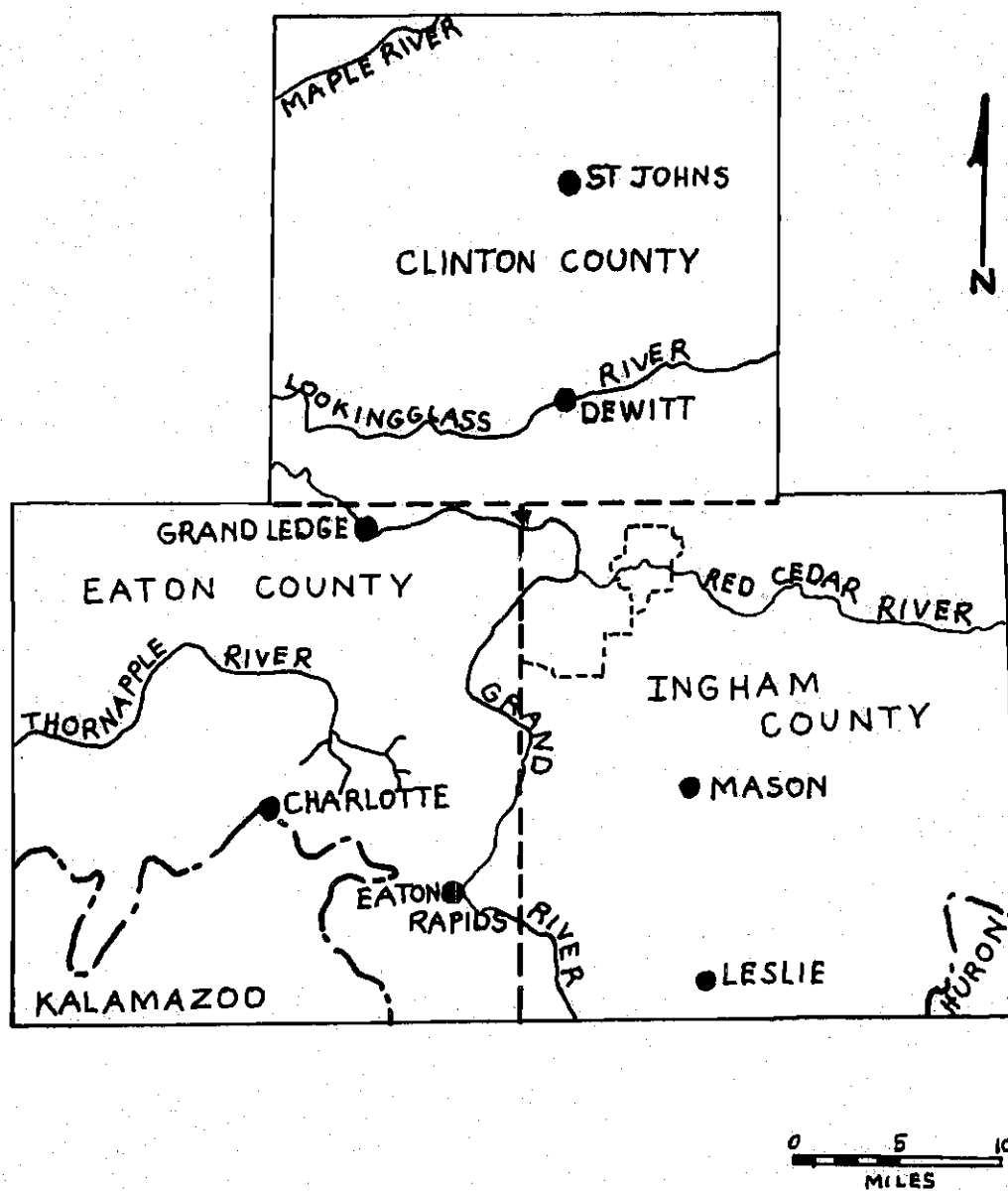


Figure D-1. Ingham County, Michigan - Major Drainage Basins

and was administered by three commissioners. In 1871, the law was changed reducing the number of commissioners to one. County Drain Commissioners are now acting under Act 40, of the Public Acts of 1956, as amended, which provides that the Drain Commissioner shall be elected at the regular general election held on the Tuesday succeeding the first Monday in November, every four years.

The Drain Commissioner has jurisdiction over all drains within his County, including those established and those in the process of construction. Under the Act of 1956, the word "drain" includes:

any creek or river, any watercourse or ditch, either open or closed, any covered drain, any sanitary or any combined sanitary and storm sewer or conduit composed of tile, brick, concrete or other material, any structures or mechanical devices that will properly purify the flow of such drains and any levee, dike, barrier, or a combination of any or all of same constructed for the purpose of drainage or for the purification of the flow of such drain.

Many of the drainage basins in Michigan are contained within several different counties. In order to effectively deal with the drainage problems within these overlapping basins, there is a drainage committee for each drainage basin. A committee is composed of the Drain Commissioners from all counties that have land area within the basin plus one representative from the Department of Agriculture. These committees have the authority to deal with drainage problems on a basin basis rather than being constricted by existing political boundaries.

The duties of the County Drain Commissioner are: first, to administer the proceedings necessary to and resulting in the construction of new drains; and, second, to supervise the maintenance of previously constructed drains.

Except for maintenance, all drain work is initiated by the people of the specific area to be drained, by petition; or petition by resolution of one or more cities, villages and townships. Such petitions may be signed solely by a city, village or township when duly authorized by its governing body or by any combination of such municipalities. The Drain Commissioner has no power to act otherwise.

As an example of the vast drainage system that is under the jurisdiction of the Drain Commissioner in Ingham County, there are approximately 780 established County drains. These total in excess of 572 miles with about 372 miles of open drains and 200 miles of tile or pipe-enclosed drains. There are also approximately 70 drains built by private developers to be taken into the County system and established as County drains for maintenance. Following is a brief outline of some of the functions that the Drain Commissioner has with regard to this vast system of drains.

1. The Drain Commissioner may make an annual inspection of all drains under his jurisdiction and may expend an amount not to exceed \$500 per mile or fraction thereof, or one percent of the original cost of the drain, for maintenance and repair of any drain unless petitioned by emergency resolution for such repair by the governing body of the municipality within which the drainage district exists.
2. The Drain Commissioner must submit a report to the County Board of Commissioners at its annual meeting in October, consisting of a financial statement of each drainage district and a report on all activities of his office during the

preceding year.

3. The Drain Commissioner processes all complaints from property owners, issues permits for taps and relocations of drains, and sees that correct boundaries for all drainage districts are maintained.
4. The Drain Commissioner assists property owners with drainage problems.
5. The Drain Commissioner is responsible for the acquisition of rights-of-way for the construction of drains.

It is the general policy in Ingham County that all engineering be performed by consulting engineers. Consulting engineers are engaged for the design and preparation of plans and specifications; however, the Drain Commissioner approves all plans, and a close liaison is maintained for purposes of permits, complaints, and payments throughout the duration of each project.

Ingham County Drainage Program

Following is a brief discussion of the more important aspects of the Ingham County Drainage Program.

Ingham County Drain Commissioner's Staff

The Drain Commissioner's staff consists of the following personnel:

- Chief Deputy Drain Commissioner
- Deputy Drain Commissioner
- Research Assistant
- Inspectors (three)
- Secretaries (two)
- Clerk

The Drain Commissioner does not have any personnel on his staff

with training in the areas of engineering, hydrology, or planning. Several of the employees do have two year college degrees and are currently working on four year degrees but these are in the liberal arts area. It is presently, and has been, the objective of the Drain Commissioner to obtain the expertise he needs in the different areas of drainage, from local private consultants in engineering, planning and law. Thus, rather than do most of the technical review "in house", the Commissioner contracts with 13 engineering firms, 7 law firms and numerous other special consultants to do this work. The Commissioner feels that this stimulates private enterprise in the area and is a better and more efficient approach than building a governmental bureaucracy to handle the work. These consulting firms work on both County projects and private projects within the County.

Commissioner's Philosophy on Drainage Facilities

The Commissioner expressed his philosophy on drainage facilities as follows:

1. use pipes and closed conduits in heavily built-up areas,
2. use grassed and natural channels in other areas.

It is the objective of the County to keep the drainage system as natural and aesthetically pleasing as possible with no use of concrete channelization. The County also emphasizes the use of any existing channel capacity for flood flows before using on-site storage or other structural measures.

Goals of the Drainage Program

Following is a list of goals that the Commissioner stated were part of the County Drainage Program:

1. flood plain management,
2. soil erosion and sedimentation control policies and procedures,
3. identification of aquifers and ground water recharging,
4. flood control and protection.

Drainage Rules and Regulations

The existing rules and regulations in Ingham County were written by the Drain Commissioner in consultation with other Michigan Commissioners, local engineers, planners and lawyers. These regulations are contained in a report entitled, "Rules for Internal & External Drainage for Subdivisions." This report contains regulations covering the following:

1. construction and design standards for proposed drains,
2. construction and design standards for improvement of drains,
3. bonding procedures,
4. plans and plats required,
5. establishing right-of-ways,
6. erosion and sediment control,
7. inspection procedures,
8. maintenance.

In addition, the Ingham County Drain Commissioner has drafted a flood plain ordinance (this ordinance had not been officially adopted when this case study was done but the Drain Commissioner had anticipated its adoption in the near future). This ordinance, unlike the other ordinances studied, makes a distinction between a floodway and a flood fringe. A floodway is defined as follows:

The channel of a stream and those portions of the flood plain adjoin-

ing the channel that are required to carry and discharge the flood water or flood flows or any river or stream including but not limited to flood flows associated with the intermediate regional flood.

A flood fringe is defined as, "that portion of the flood plain outside the floodway."

The ordinance goes into a considerable amount of detail as to what uses are permitted within the floodway and flood fringe districts. Uses which have a low flood damage potential and do not obstruct flood flows are permitted within the floodway. Some examples would be agricultural uses, recreational areas such as golf courses, parking areas, residential lawns and gardens, etc. Some uses which require structures, fill, storage of materials or equipment, may be permitted within the floodway with the issuance of a special exception. Some examples of these would be circuses, drive-in theaters, marinas, railroads, stables, etc.

The ordinance does state that no structure (temporary or permanent), fill (including fill for roads and levees), deposit, obstruction, storage of materials or equipment, or other use may be allowed which, acting alone or in combination with existing or future uses, unduly affects the capacity of the floodway or unduly increases flood heights. In addition, this ordinance has provisions regulating the following:

1. filling in flood plain areas,
2. erosion and sediment control in flood plain areas,
3. specific criteria to be used in locating structures in flood plain areas (e.g., not to use structures for human habitation, firmly anchor structures to prevent flotation, regulations for utility installation, etc.),

4. storage or processing of materials in flood plain areas.

Drainage Plans

The Drain Commissioner does require a drainage plan and hydrologic study for each development. The plans are reviewed by the Commissioner but the hydrologic study is not, unless for some reason the Commissioner deems it necessary. The rational method is now used as the basis for the hydrologic studies. The 10-year one hour storm is used as the design storm for all drainage facilities with the 100-year storm used in calculating the limits of the flood plain. The drainage plans also include proposed soil erosion and sedimentation control measures. It has been the policy of the Drain Commissioner that inspectors from the Commissioner's office be used to inspect private development projects to be sure the drainage plans are implemented.

On-Site Storage

According to the Drain Commissioner there are several purposes for the use of on-site storage:

1. aesthetic,
2. flood control, and
3. ground water recharging.

It was stated by the Drain Commissioner that the ground water supply within Michigan is continually being depleted (at approximately one foot per year) and that on-site storage was one means of recharging this supply.

Ingham County has not included on-site storage within its rules and regulations as the solution to all drainage problems but instead studies each development on a case-by-case basis and only requires

storage when it proves to be the best solution to the problem at hand.

When on-site storage is used, the following design criteria are used for all drainage areas:

1. The size of the retention basin must be large enough to contain the 25-year one-hour storm excess (inflow minus allowable outflow) calculated using fully developed conditions.
2. The design for the outlet of the basin is based on a two-year thirty-minute storm.
3. The design of the retention basins that have been constructed within Ingham County has been based on the SCS Hydrograph Analysis Method.
4. The design for the structural adequacy of the retention basins and the overflow spillways are based on the 100-year storm.

These design criteria were arrived at by the Drain Commissioner in consultation with local engineering consulting firms. It is the opinion of the Drain Commissioner that retention basins based on any larger storms would consume too much land and would be uneconomical.

Miscellaneous Aspects of the County Drainage Program

The structural adequacy of any proposed drainage facility is checked for the County by one of its consulting engineers. All dams and bridges are designed for the 100-year storm.

Michigan law prohibits any filling in a designated flood plain without a permit from the Drain Commissioner. The law states that any proposed filling cannot decrease the storage area of the flood plain so that it cannot contain the 100-year storm.

In order to construct any utilities within a flood plain, a permit is required from both the State Department of Natural Resources and the Drain Commissioner. In Ingham County all utilities must be placed a minimum of four feet below the invert of the stream. The Drain Commissioner reported that the County has not experienced any problems with utilities being located within the flood plain areas and they have numerous gas, electric, telephone and other utilities located within these areas.

The Drain Commissioner has two crews that continually maintain the existing drainage system. These crews work in areas of the system that are known to have caused problems and also do some preventive maintenance to prevent future problems.

Problems with Ingham County's Drainage Program

According to the Drain Commissioner, the only major problem that is impairing Ingham County's Drainage Program is that the County Commissioners are only part-time employees. The Drain Commissioner feels that the existing governmental functions are too large and numerous for part-time employees. In addition to this, there are several improvements that the Drain Commissioner would like to make in the drainage program.

1. There is a need for an ordinance to specifically deal with soil erosion and sedimentation control.
2. A better stream and raingauge network within the County is needed.
3. In order to do an adequate job of inspection, more County inspectors are needed.

Hydrologic Simulation Program (2)

One facet of Ingham County's Drainage Program which differs from the programs of the other areas included in this research, except Fairfax County, is the use of a hydrologic simulation program. Although this program was not completed at the time this study was conducted, its preparation was almost completed and some of the anticipated effects can be discussed.

Ingham County used four major objectives to evaluate the potential of using a hydrologic simulation program.

First, the County wanted a method which would be more accurate than current hydrologic methods used in the County. At the present time the rational formula is used as the basis for most of the hydrologic studies.

Second, the County was looking for a method which could analyze the effects of further urbanization on the County drainage system.

The third objective was to find a method capable of calculating the interrelationships between drainage systems. For example, what effect does one storm drain network have on the flooding of an adjacent network?

The final objective was to find an economically efficient method, one which would not lead to designs which are inadequate for anticipated development and in need of replacement or, conversely, highly overdesigned for all time.

With the aid of Systems Research, Inc., the County selected the Hydrological Simulation Program (HSP) of Hydrocomp Inc. to meet these objectives.

HSP is a general mathematical model of the land-phase and channel routing of the hydrologic cycle. It uses rainfall, pan evaporation, temperature and other meteorological data and channel data as inputs and calculates snow-melt, infiltration, overland flow and other hydrologic processes involved in runoffs to provide a detailed hydrograph of streamflow. Outputs of the model include mean daily, hourly, monthly and annual streamflow; data on snow pack and water content, soil moisture storage and actual evapotranspiration. Continuous detailed graphical output on selected model components may also be provided.

The simulation program is adaptable to any watershed by using input parameters that correspond to the physical characteristics of the watershed. It can be used to extend short streamflow records, or to create data for ungaged streams. The simulation can be adjusted to show the effects of urbanization, or to indicate the hydrologic characteristics of an area after urbanization changes take place. In addition, flood stages can be simulated for use in flood plain mapping.

For purposes of urban drainage design, continuous hydrographs at critical points within a complex drainage system can be calculated. With pipe diameter and roughness, surcharge conditions and mixed closed and open conduits can be modeled. The simulation programming automatically abstracts maximum flows and calculated peak flow frequencies at any point in the drainage system. Urban development levels are accounted for through an impervious area parameter and through channel network characteristics. Normally the minimum size area that HSP can accurately deal with is 30-40 acres, but Dr. Hey, of Hydrocomp Inc., feels that the model could be tuned for any size area. Since the impervious param-

eter goes from 0-100 percent, any change in the impervious area can be detected by the model. Thus, the model could be used to detect differences of runoff as small as one cubic foot per second (cfs) but the accuracy of the model would not be as good in dealing with very small areas as it would be on large areas. The accuracy of the model will also depend on the quality of rainfall data available for the area being simulated. The time periods for which data is available (1 min., 15 min., 1 hr., etc.) and the length and accuracy of the rainfall record are important considerations.

The following specifics of applying HSP to the Ingham County area were revealed by the Drain Commissioner. The model was calibrated on a long term basis by using yearly data, then monthly and daily data were used. Hydrocomp then used 10-12 storm events and visually checked the storm hydrographs of these short term events. The model was calibrated on a hypothetical watershed where a flood frequency distribution was generated. Then the model was used to generate a flood frequency distribution for the Slone watershed in Ingham County. The results of these distributions showed a 90 percent correlation between what was expected and the actual distribution from the Slone watershed.

The model uses 15 minute rainfall data and in many cases, Hydrocomp had 25 years of measured data to use in calibrating the model (there are nine rain gages in Ingham County that were used for this project). Hydrocomp also used several different configurations of industrial, commercial and residential land uses for sensitivity tests. Except for infiltration rate, the parameters used in the model are physically based (e.g., land slope, impervious area, vegetation cover, etc.).

Thus, it was possible to input existing and proposed physical characteristics of Ingham County into the model.

The Drain Commissioner feels that HSP is a more accurate way of predicting flood flows than the currently used rational formula since HSP considers the entire hydrologic cycle instead of only one or two aspects of it. In addition, the effects of anticipated urbanization can be studied through HSP and comparisons of alternate drainage designs can be made. Once the model is calibrated and established for Ingham County, it can be used for all drainage designs and evaluations and can also be updated to reflect changes in the physical characteristics of the County.

HSP will also play an important part in the flood plain studies in Ingham County. At the present time the limits of the flood plain areas within the County are based on the Corps of Engineers Flood Plain Information Studies. It is expected by the Drain Commissioner that the HSP model will reevaluate these flood plain limits as on-site storage and other structural measures are completed. Thus, the flood plain limits will change in accordance with the results obtained from the model. By changing the limits of the flood plain areas as structures are built, some land may be removed from the flood plain restrictions and can then be used for development. HSP will also be used to check some of the existing flood plain limits.

By combining all of these functions, HSP will be used to obtain a comprehensive drainage plan for the County. This plan will be dynamic in nature in that it will be continually evaluated and updated. This will give the Commissioner's staff the ability to evaluate all proposed

development and also evaluate alternative development plans and the effects of these plans on the County Drainage Program.

As far as the economics of using HSP is concerned, the Drain Commissioner feels that the existing charges that the developers pay the County to review their plans will cover the cost of using HSP to evaluate the planned development. The developer will be required to submit a site plan of the proposed development and then the Commissioner's staff will calculate and measure the information needed to use the HSP model. The Commissioner will have a computer terminal located in his office which will be connected to a computer in Stamford, Connecticut, where the model is located. The model will be continuously updated for use in Ingham County by the Deputy Commissioner.

Consulting Engineers in Ingham County

Several interviews were conducted with local engineering consultants to get their views of the County's program. The general opinion was that the County's Drainage Program depended a great deal on who held the job of Drain Commissioner. Since the Drain Commissioner is an elected political official he doesn't need any background in engineering or drainage to get the job, or even an appreciation for the problems involved. The consultants agreed that the present Commissioner did have a real concern for the local drainage problems which was reflected in a sound practical drainage program.

Since the HSP model was not operative when this study was done, the consultants could not comment on its use or effectiveness. Several consultants did state that they didn't feel there was a need for more

sophisticated hydrologic methods than what were presently used and they hoped that HSP would not add complexity and cost to the development of land.

The only major complaint that the consultants had was that drainage was only one aspect in the development process and that they had to go through several other commissions and boards before they could develop their land. They expressed the desire to have more coordination between the different departments of the local government.

Concluding Remarks

With the use of HSP, Ingham County will have one of the most sophisticated drainage programs in the Country. As the Drain Commissioner states, "I believe we will be years ahead of other counties. We are developing the state-of-the-art and we can be one of the first to utilize these new techniques." The County is spending over \$200,000 to put the model into practice but feels that this cost will be returned to the taxpayer with more efficient drainage facilities in the years ahead.

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6. Numerous Ingham County memos, letters, reports, regulations, and ordinances pertaining to drainage.
7. The following persons were interviewed or their opinions were obtained concerning certain portions of the material contained in this case study:

Richard L. Sode	.....	Ingham County Drain Commissioner
Walter S. Sowles	.....	Director, Division of Socio- Economic Research, Systems Research Incorporated
Don Hey	.....	Vice President, Hydrocomp, Inc.
Herbert Norton	.....	Michigan Townships
Donald Hodney	.....	Donald Hodney Builders
Jerry Nilson	.....	Nilson and Nilson
Ken Hope	.....	Home Assistance Corporation
Doug Weir	.....	Engineer, Snell Engineering
Robert Keuhne	.....	Planner, Tri-County Regional Planning Commission
James Barado	.....	Miller, Confield and Associates
Phyllis R. Dodson	.....	Executive Director, Lansing Home Builders Association

APPENDIX E

CITY OF TAMPA, FLORIDA

The City of Tampa is located along the west coast of Florida in Hillsborough County. Following is a general discussion of the natural environment of Tampa and Hillsborough County (1). Because of some of the unique characteristics of this area, a more detailed discussion of the natural environment will be given than was included in the other case studies.

Climate

Tampa's climate is subtropical with long hot summers and short mild winters. This combination produces a mean annual temperature of 72.2 degrees Fahrenheit. Although the summers are hot, thunderstorms prevent extremely hot temperatures. The all time record high temperature is 98 degrees Fahrenheit which occurred last on June 26, 1952. These extremes occur in late June when the rainy season is slow in beginning. The mean winter temperatures preclude a tropical climate for Tampa. Frost occurs almost every year and on rare occasions, a freeze will envelope the area. Tampa's all time record low temperature, 18 degrees Fahrenheit occurred in 1962.

Summer thunderstorms accent Tampa's climate and are one of its most unusual weather phenomena. Tampa records a mean of 91 days each year with a thunderstorm. This is the largest rate of occurrence in the United States. Most of the thunderstorms occur during the summer rainy

season that usually starts in mid-June and extends through mid-September. This rainy season produces 60 percent of Tampa's mean annual rainfall rate of 49.23 inches (2). A typical summer thunderstorm will cause the temperature to drop from the low 90's to the low 70's.

Hurricanes exert their influence on Tampa on the average of once in ten years. Hurricanes have brought Tampa's heaviest 24 hour rainfall (12.11 inches), highest wind speed (SE 75 mph), highest tides (15.0 feet above mean low water), and the lowest barometric pressure (28.15 inches of mercury). Although hurricanes can be very destructive, they usually become assets in that they replenish the water supply.

Topography

Hillsborough County's topography is divided into two general types, sandy hills and flatwoods. The sandy hills are remnants of pre-historic beach ridges and sand dunes; hence today these hills are very sandy and dry. As the name implies, these areas contain gently rolling hills, numerous lakes, and very few streams. One of the major physical features is that almost all rainfall is absorbed into the soils, practically eliminating surface runoff. Most of Tampa is located on sandy hills.

The flatwoods are prehistoric bay bottoms. They are topographically flat and can usually be identified by the natural vegetation of the pine and palmetto forest. The flatwoods are periodically flooded, contain a high water table and have very acid soils. Within the flatwoods are scattered lakes, ponds, cypress domes and river swamps. Although the drainage is poor, most streams within the County are found in the flatwoods.

These two regional types are very general and each contain exceptions. For example, each are interlaced with swamps. The importance of these regions is their effect upon the development pattern of Hillsborough County and peninsular Florida. Most viable cities and towns in Florida are located on higher and drier land, meaning some type of sandy hills or ridges.

Land Forms

The term "land form" is applicable to each of many features that taken together make up the earth's surface. In Hillsborough County, one form predominates - a coastal plain. Other common land forms are lakes, hills, rivers, and a shoreline.

The most unusual land forms within the County fall under the category of Karst topography, which encompasses springs, caves, sink holes, natural bridges, and disappearing streams. Karst forms have developed over thousands of years when limestone is dissolved by weak amounts of carbonic acid found in rain water. Underground cavities develop through which water flows and surfaces as springs. If the roof of an underground cavity collapses, the resultant land form is known as a sink hole. If sufficient time has passed, the sink hole will become a lake or pond known as solution lakes. Many lakes within Hillsborough County are remnants of prehistoric sink holes. If a stream flows into a sink hole and disappears, this land form is referred to as a disappearing stream.

Drainage Basins

Hillsborough County's drainage pattern consists of three rivers

and numerous creeks (Figure E-1). The rivers are, from the largest to the smallest, the Hillsborough, the Alafia, and the Little Manatee. The Hillsborough River shares a common source with the Withlacoochee that originates in the Green Swamp (Polk, Lake, and Pasco Counties), flows southwest through Tampa and empties into the Hillsborough Bay. Both the Alafia and the Little Manatee rise in Polk County and flow westward into Tampa Bay. Some of the major creeks that flow into the bay are Bullfrog, Palm River, Sweetwater, Rocky, and Branch. Other large creeks within the County are Cypress, Trout, Blackwater, and Pemberton, each of which flows into the Hillsborough River. With minor exceptions, all stream basins drain the flatwood areas.

Large areas of the County contain no streams for drainage. These areas are the sandy hills where most drainage is internal or vertical. In these areas only on rare occasion will the ground become wet enough for surface runoff to occur. Usually, the sandy hills have lower water tables than do the flatwoods. In areas of sandy hills that have a moderately high water table, numerous lakes will be found.

Water Resources

Water represents one of the County's most valued resources. Although the County averages approximately 50 inches of rainfall annually, there are limits to the amount of water that can be used without degrading the natural environment and the quality of life. Because this limit has been exceeded in many areas, some areas are experiencing such adverse effects as salt water intrusion and depressed water tables. Severe drops in the water table occur when the pumping rate exceeds the minimum

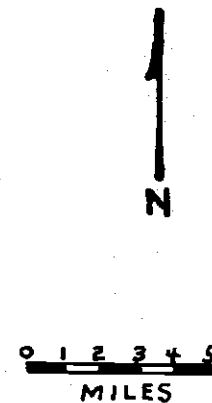
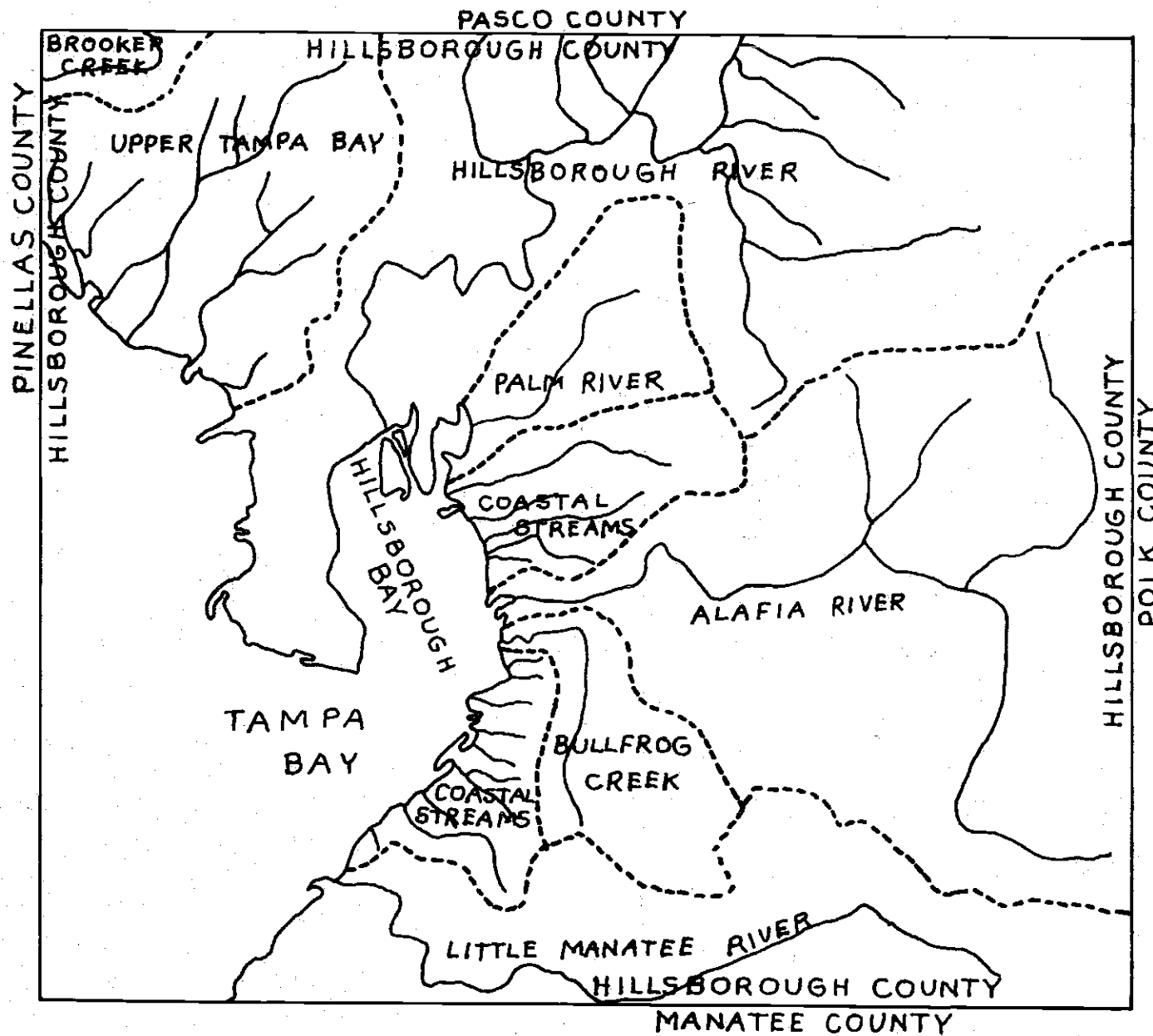


Figure E-1.
City of Tampa, Florida
Major Drainage Basins

amount of rainfall or the recharge rate. Extreme overpumping has occurred in the western portion of Polk County as a result of the phosphate industry's operations. The result is a lowering of the water table in eastern Hillsborough County where the City of St. Petersburg and Pinellas County have established well fields. In this case numerous shallow water wells and lakes have depressed water tables.

The initial water supply for the City of Tampa was from wells tapping the surface aquifer. Because of salt water intrusion and increased water demands from a growing population, Tampa was forced to seek additional water sources. During 1925, the Tampa water works began pumping water from the Hillsborough River.

Presently, the dam and reservoir on the Hillsborough River is inadequate. The system pumped 16,265,000,000 gallons in 1970 (3). The reservoir was the primary source, but during the spring months, when the Hillsborough River flow is at the lowest volume, Sulphur Springs serves as an auxiliary source.

By 1990, the Hillsborough County Planning Commission projects that metropolitan Tampa's water needs will increase by 48.7 percent to approximately 24,000,000,000 gallons annually (4). Tampa is planning to meet this projected demand by establishing a well field northeast of the City (in the Hillsborough River Basin) in conjunction with Southwest Florida Water Management District.

Another important water resource is Tampa Bay. Man is attracted to the shoreline for homesites and commercial establishments; he enjoys the bay as a place to swim, sail, and fish; and he uses the waters for commerce and the production of electric power. Ironically, the shore-

line has been altered for urban development, destroying spawning grounds for fish; the City of Tampa dumps primary treated sewage effluent into the bay, degrading swimming, fishing, and sailing waters. Phosphates and nitrates are dumped into the bay which ultimately causes odors from dying fish and vegetation. The phosphates are effluent from the large phosphate mining and manufacturing industry located in this area.

Sewage effluent is a major source of nitrates.

A 60 million gallon per day advanced waste treatment plant is now under construction by the City of Tampa which is designed to remove 90 percent of suspended solids, BOD₅, phosphorus, and nitrogen.

Soils

Soils are made of a combination of decomposed and disintegrated rocks, water, air, and microscopic plants and animals. Descriptions of the County's soils are best set forth by the following quotation by the United States Soil Conservation Service (5).

The soils of Hillsborough County are similar in some characteristics and qualities, but vary greatly in others. As a consequence, they have a wide range of suitability for agricultural use. In general, they are nearly level or gently sloping, acid, very sandy, very permeable, low in clay, low in organic matter, and low in plant nutrients. Their natural drainage, however, ranges from very poor to excessive. Some are underlain by calcareous materials, and some have loose acid sand to a depth of several feet. Approximately 176,000 acres of solids have a brown-stained pan at depths of 14 to 42 inches, whereas other solids are entirely free of this layer.

Major Flooding

There is very little information available about the floods that have occurred in the Tampa area. The maximum known flood on the Hillsborough River in the vicinity of Tampa occurred in September 1933. The

second highest flood was that of March 1960, the greatest of three damaging floods in 1960. To give some idea of the severity of these floods, the U.S. Geological Survey has estimated from their gage on the Hillsborough River that a flood with a return period of nine years would have a 14.2 foot stage on the Hillsborough River. The September 1933 flood had a stage of approximately 19.5 feet while the stage of the March 1960 flood was 16.5 feet.

There is no information concerning the damage caused by these floods or the possible damage that might result from a major flood with a return period of 50 or 100 years. The U.S. Corps of Engineers is presently working to establish the 100-year flood plain on Flood Plain Maps of the City. It is anticipated that these maps will be available in the mid 1970's. It was estimated by the City personnel that a considerable amount of existing development is within the 100-year flood plain. There is also some proposed development that will probably be within the 100-year flood plain.

City of Tampa's Drainage Program

Following is a brief discussion of the more important aspects of the City of Tampa's Drainage Program.

Goals and Objectives

The public works personnel reported that no specific goals or objectives have been formulated for their drainage program. They did state that their major goal was that the entire City should have a drainage system to protect everyone against damage from a storm with a 5-year return period.

City of Tampa's Regulations Pertaining to Drainage

Following is a brief discussion of the City of Tampa's regulations pertaining to drainage.

1. Section of the general zoning ordinance entitled, "Grading, Filling, Excavation and/or Removal of Soil and Earth Products, Permit and Bond Required, etc." - This section of the zoning ordinance is concerned with regulating development so that it will not affect surface drainage so as to damage surrounding areas.
2. Zoning ordinance entitled, "Site Drainage and Grading Plans" - This ordinance gives the conditions under which site drainage and grading plans are required and the specific items which should be included in such plans (including appropriate calculations).
3. Several sections of Tampa's Subdivision Regulations which relate to drainage - These regulations are primarily concerned with the details of preparing and submitting drainage and site plans.
4. City of Tampa's Department of Public Works recommended design criteria for retention basin design - These design criteria give the specific details of retention basin design (size of basin, bottom and side slopes, inlet-outlet design, landscaping, etc.).
5. A proposed new section to the City of Tampa's Zoning Ordinance entitled, "Regulation of Flood-Prone Areas" - This section of the zoning ordinance would regulate the developments

located within the 100-year flood plain as determined by the City. This section also deals with fills in the flood plain area, flood-proofing measures, plans required, variances, and appeals.

City of Tampa's Storm Water Retention Program

In 1969 the City of Tampa's Public Works Department did a study of the entire City and selected areas for possible retention sites. These sites were then delineated on maps. These maps are used both to inform the engineers where the best retention sites are and to inform the public which land will probably be used for retention sites. After the sites are selected, the retention basins are designed and then the City purchases the needed land for these basins.

The cost of these retention basins is distributed on a cost sharing basis to the developers involved (those whose development causes the increased runoff). A developer contributes according to the amount of runoff from his development calculated as a percentage of the total runoff to the retention basin. This cost sharing system is now only on a voluntary basis but the City personnel report no major problems in obtaining the funds from the developers.

Retention basins are not required for every development but only on a case-by-case basis. The Public Works Department determines whether a development will need retention or not. Usually this determination is based on the capacity of the existing storm sewer system. The City of Tampa has done some economic analysis of existing and proposed retention basins and their results show about a 20 percent saving by using retention basins rather than increasing the capacity

of the sewer system to a capacity that would handle the increased runoff. Retention basins that have been built are located within areas of the City where the price of land is relatively low.

In order to gain public acceptance of the use of retention basins, the City has found that proper landscaping is an important element in their design. The City now spends a considerable amount of money for landscaping these areas.

Hydrologic Studies

A hydrologic study is required for every development within the City. The Public Works Department has recently proposed that small developments (1/2 acre or less) be exempt from this requirement.

All of the hydrologic studies completed to date have been based on the rational method. The largest development where the rational method was used is approximately 500 acres. The City personnel expressed the opinion that since they are working in an urban area where the developments are almost always serviced by storm sewers, the rational method is satisfactory and they are not anticipating the use of any other methods in the near future.

The City uses a hydrologic method for retention design called the Method of Instantaneous Runoff. Essentially this is the same method that DeKalb County, Georgia is now using which is based on the rational method. The City personnel stated that this method has been used for retention design by the State of Florida for 10 - 15 years and the method is widely accepted by local counties and cities.

Flood Plains

At the present time, the City does not have maps showing the

limits of the 100-year flood but these maps are being prepared and should be available in the mid 1970's. The City does have maps showing the areas inundated by the peak recorded floods. Much of this information is based on the 1960 flood, the last severe flood in the Tampa area. The City has not adopted any general restrictions on development in flood plain areas but has handled development on a case-by-case basis. The City personnel reported there is still development being proposed and built in flood plain areas.

Maintenance

The City maintains only the drainage network within their right-of-way and drainage easements that have been accepted for maintenance. Those drainage works located on State property are maintained by the State. Where drainage works are located on private land, the maintenance responsibility is left up to the owners of the property; however there are numerous old drainage ditches where public easements have not been granted or acquired and these are maintained by the City. The City used to require small retention basins to handle the runoff from single developments but found these became maintenance problems and that larger basins were better. The City has also found that basins without outlets have not functioned as efficiently as they were designed because of fine sediments filling the voids in the soil and reducing the percolation rate.

Role of the Planning Department

The Public Works Department drafted the ordinances dealing with drainage while the Planning Department has functioned as a reviewing agency. The Planning Department has been more interested in the

broader aspects of planning than in dealing with the City's drainage problems.

Major Changes in the Drainage Program

The major change that has occurred in the City of Tampa's Drainage Program is from a philosophy of getting the water off the land as quickly as possible to one of retaining the water in retention basins.

Drainage Section of the Public Works Department

In the Drainage Department there are five graduate engineers. The department personnel stated that they have time only for the day-to-day work and thus do very little planning related work. In addition to new construction, the department receives about 8 - 10 new drainage complaints per month. The department now has about 120 current drainage problems which need the installation of storm sewers.

Concluding Remarks

Although Tampa has a very different climate and topography compared to the other areas studied, their approach to drainage and flood control is quite similar. Tampa's use of storage facilities, delineation of flood plain areas, and erosion and sediment control regulations are similar to many of the areas studied. The main difference in Tampa's regulations is the inclusion of a large amount of detail concerning flood-proofing and retention basin design which was not included in the other ordinances studied.

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9. Numerous City of Tampa memos, letters, reports, regulations, and ordinances pertaining to drainage.
10. The following persons were interviewed or their opinions were obtained concerning certain portions of the material contained in this case study.

City of Tampa Public Works Department

Wayne Jump	Public Works Director
Charles W. Matheny, Jr.	Assistant Director
Charles Skillman	Drainage Engineer
Donald Terp	Assistant Director of Engineering
Del Fernandez	Engineer
Gerald Seaburn	United States Geological Survey
Garry Ellis	Planner - Hillsborough County Planning Commission

Kurt S. Frahn	Water Resources Engineer - Tampa Bay Regional Planning Council
Kenneth Bryant, Jr.	Vice-President - Diaz, Seckinger & Associates, Inc.
William Poole	President - Poole Engineering Company
James Bingham	Engineer - Poole Engineering Company
Jack Holmes	Landscape Architect - Poole Engineering Company
Herman Massey	Superintendent Parks - City of Tampa
James Moore	Executive Director - Greater Tampa Home Builders Association

VITA

Thomas Neil Debo was born in Hamburg, New York, on September 10, 1941. He is the son of Mrs. Thelma Lonergan. After graduating in 1959 from Hamburg High School, he attended the State University of New York at Alfred and received the degree of Associated in Applied Science in 1961. He then graduated with honor from Michigan College of Mining and Technology, in 1963, with a Bachelor of Science in Civil Engineering. After seven years of industrial and government employment he attended the Georgia Institute of Technology and received the degree of Master of City Planning in 1972. After completing the requirements for the masters degree he continued his graduate work toward the degree of Doctor of Philosophy in Civil Engineering majoring in Hydrology and Water Resources Planning. Presently Mr. Debo is a Senior Water Resources Planner with Hydrocomp, Inc.

Mr. Debo is currently a member of the American Geophysical Union, Tau Beta Pi, Phi Kappa Phi, and Chi Epsilon.

He was married in 1963 to the former Miss Gail Anne Biddlecombe, and they have two daughters, Annette Renee and Kathleen Michelle.